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THE MOSAIC DISEASE OF SINCAMAS, PACHYRRHIZUS EROSUS (LINNÆUS) URBAN

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SIX PLATES

INTRODUCTION

The senior writer, while working with bean mosaic at the University of Wisconsin, noted a mosaic disease on *Pachyrrhizus erosus* (L.) Urb. in the pathological greenhouse. On his return to the Philippines, many other species of host plants affected with mosaic disease have been observed. Among these plants, the sincamas, *Pachyrrhizus erosus*, is one commonly affected. This plant is a native of Central America, but is now widely distributed throughout the Tropics. In the Philippines the sincamas either grows wild in thickets or is cultivated on a commercial scale for its sweet, fleshy taproot. This fleshy root is eaten raw, made into salads, or, when cooked, is mashed and eaten like turnips. Since the mosaic disease of sincamas is very common, and because of the economic importance of this food plant in the Philippines, an investigation of the disease should prove of value. It is, therefore, the purpose of this paper to report our observations and findings on the subject, particularly concerning the artificial and natural transmission of the disease and the chemical composition of the fleshy taproots of healthy and of mosaic-infected plants.

[1] The writers are grateful to Dr. W. H. Brown, director, Bureau of Science, and to Dr. C. J. Humphrey, mycologist, Bureau of Science, for helpful suggestions in the preparation of this manuscript.

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GEOGRAPHIC DISTRIBUTION, OCCURRENCE, AND ECONOMIC IMPORTANCE

As far as the writers are aware, no report of the mosaic disease of the sincamas is found in literature. In the Philippines, the disease is very common in both cultivated and wild sincamas. It was observed in nearly all the provinces of Luzon visited where the sincamas is grown, and it probably occurs in other islands of the Philippines. From 30 to 100 per cent infection has been noted in most of the fields in the towns visited; namely, Mariquina, Rizal Province; Calamba, Laguna Province; Balayan, Batangas Province; Laoag, Ilocos Norte Province; Bauang, La Union Province; and several towns of Pangasinan Province.

As is true with a number of other minor crops in the Philippines, no authentic data on yield per hectare or loss due to mosaic disease are available. Since the disease affects the photosynthetic activity of the leaves, the fleshy root is generally reduced in size, depending upon the time of infection (Plates 4, 5, and 6). Likewise, as will be discussed later, the chemical composition of the root is altered by the presence of the virus.

GENERAL SYMPTOMS AND EFFECTS OF MOSAIC

The symptoms displayed by a sincamas plant infected with mosaic in the field or in the greenhouse are variable, as is the case with the other virus diseases.(6, 8) In general, varying degrees of mottling or chlorosis, and blistering of the leaves are noted (Plate 1, figs. 1, 2, 3; and Plate 2). The mosaic-infected plants are rarely killed, and in certain instances, plants with well-marked symptoms will later show only slight mottling or complete absence of symptoms on the succeeding leaves, and may remain as vigorous as the healthy ones. When infection takes place early and the symptoms are severe the plants are usually stunted, dwarfed, or spindly (Plate 3, fig. 2) and the leaves, as well as the fleshy taproot, are greatly reduced in size (Plate 4, fig. 2; and Plate 5, fig. 2). However, when plants are infected later in the season, the growth may be only slightly affected and the fleshy root only slightly reduced in size, if at all.

When healthy plants become infected during the growing season through the agency of insects or through artificial means, the first evidence of mosaic symptoms is observed in the young expanding leaves ten to fifteen days after inoculation. These leaves may be stiff, thickened, or chlorotic. The succeeding leaves show characteristic mosaic symptoms similar to those produced by plants originating in infected seeds.

As will be shown later, the sincamas mosaic is transmitted through the seeds of infected plants. The appearance of typical mosaic symptoms on seedlings originating from infected seeds may develop early and are manifested either by chlorosis, mottling, or blistering of the simple or first compound leaves of the plant. Under certain circumstances, however, these symptoms are delayed so that the first leaves may appear healthy or may show only a slight crinkling or a slight twisting of the leaf blades. The typical mosaic symptoms, indistinguishable from the field or greenhouse symptoms, however, are later produced on the succeeding leaves. Plate 3, fig. 2, is a photograph of a young plant infected from the seed, showing chlorosis and twisting of the simple and compound leaves.

No characteristic symptoms are noted on the green pods, on the fleshy taproot, or on the seeds of mosaic-infected sincamas plants to distinguish them from those of healthy plants. Except for size, it is difficult to recognize any other differences between the infected taproot and the healthy one. The seeds from both healthy and infected plants look alike, in spite of the fact that some of those from the infected plants contain the virus.

DISTRIBUTION OF THE VIRUS IN INFECTED PLANTS

The virus of sincamas mosaic appears to be systemic. Its presence is most easily demonstrable in the plant parts that exhibit mosaic symptoms. Artificial inoculations with juice from the leaves and stems of an infected plant readily produce infection in young healthy plants. Attempts to inoculate young healthy plants by the watery juice of the taproot from mosaic plants, so far, have given negative results. Surface sterilization of seeds from infected plants with mercuric chloride ($HgCl_2$) (1 : 1,000) has no appreciable effect on the percentage of seed transmission, and this holds true whether or not the seed coats are removed before sterilization. This seems to indicate that the virus is not located in the seed coats but is likely present in the embryo of the seed, as in bean mosaic.(6)

TRANSMISSION OF SINCAMAS MOSAIC BY NATURAL MEANS

In several series of experiments conducted with the object of infecting healthy plants by natural means, negative results were obtained through infected soil, by contact with roots of infected plants, and also by contact with aërial parts of diseased plants.

In the attempt to transmit infection through the soil, seeds of healthy plants were planted in soil mixed with fresh, dried, or decomposed mosaic tissues. No infection resulted after fifty

days, indicating that the virus does not retain its infectious properties in dead tissues of infected plants and is perhaps never transmitted through the soil from one season to another.

To determine whether the disease is transmitted by root contact, seeds of healthy and mosaic plants were planted together in a pot and the roots allowed to intermingle. No positive results were obtained.

The attempted transmission through contact with aërial parts of diseased plants was performed by allowing the vines of infected and healthy plants to intertwine, and the leaves to rub together casually under controlled conditions. No infection of the healthy plants resulted.

From the results of the above experiments, it is seen that the sincamas mosaic is not readily transmissible through cultural practices and, therefore, these practices are probably insignificant factors in the transmission of the disease in the field.

TRANSMISSION OF SINCAMAS MOSAIC BY ARTIFICIAL MEANS

Leaf inoculation.—The methods of artificial inoculation known to transmit tobacco or cucumber mosaic were tried with sincamas mosaic, but the results were negative. Successful inoculations, however, were obtained by using the leaf-mutilation method employed by Fajardo(6) in the artificial transmission of bean mosaic. In these trials from 40 to 80 per cent infection was obtained. Typical symptoms developed fifteen to twenty-five days after inoculation.

Transmission by insects.—Field observations indicated that the increase in the percentage of field infection might be due to insects. Five plants protected from insects by cloth cages remained healthy, while plants not protected from insects showed 100 per cent mosaic infection before the end of the season.

In two series of plantings made in the pathological plot in Manila, seeds of infected plants were sown from 3 to 5 centimeters apart in a 1-by-6-meter plot. The percentage of seedlings infected from seed origin was recorded, and the rate of field transmission observed each month. It was found that the increase of field transmission was associated with the appearance of the mealy bug *Ferrisia virgata* Ckll.,[2] and whenever plants became infected, this insect was usually found. As shown in Table

[2] The writers are indebted to Dr. L. B. Uichanco, professor of entomology, University of the Philippines, for the determination of the mealy-bug species.

1, the rate of spread starts slowly, and gradually increases until 100 per cent infection is reached.

TABLE 1.—*Showing the rate of spread of sincamas mosaic in the field.*

SERIES 1.

Plot.	Total plants observed.	Plants infected from seed.	Plants infected in the field.	
	February 12, 1931.[a]	February 12, 1931.	March 12, 1931.	May 12, 1931.
		Per cent.	*Per cent.*	*Per cent.*
Plot I	96	17.8	41.6	100
Plot II	104	26.0	51.8	100
Plot III	114	35.0	65.8	100
Plot IV	106	27.3	68.1	100

SERIES 2.

	April 12, 1931.[b]	April 12, 1931.	May 12, 1931.	June 12, 1931.
Plot I	104	28.0	42.3	100
Plot II	52	11.5	17.8	100
Plot III	93	31.2	40.2	100
Plot IV	40	20.0	22.5	100

[a] Seeds planted December 20, 1930. [b] Seeds planted March 10, 1931.

Controlled transmission experiments with F. virgata Ckll.—Controlled experiments in the greenhouse with mealy bugs (*F. virgata*) thus far have failed to transmit the virus readily to healthy plants. Seeds of healthy plants were sown in greenhouse benches or in pots covered with celluloid cylinders[a] immediately after planting. As soon as the plants were in the third to sixth compound-leaf stage, ten average-sized mealy bugs reared on mosaic plants were transferred to each plant. In two series of experiments conducted in the above manner, no infection developed on the ten healthy experimental plants at the end of thirty-five days when the final notes were made.

In another set of experiments, mosaic and healthy plants were grown together in the same pot and caged immediately after planting with celluloid cylinders. Mealy bugs from infected plants were then introduced into the cage and allowed to colonize on both mosaic and healthy plants. At the end of two months when the final notes were made, only slight chlorosis was noted on the leaves from the five healthy plants under observation. Plate 6 shows the celluloid cylinders and the mealy bugs, *F.*

[a] Humphrey, C. J., Philip. Journ. Sci. 48 (1932) 259.

virgata, used in the attempts to transmit the virus to healthy sincamas plants.

The results of the above experiments in the greenhouse seem to indicate that the common mealy bug cannot transmit the virus readily to healthy plants. It is, therefore, doubted at present whether this insect plays any rôle in the spread of sincamas mosaic in the field. In this connection it must be considered, however, that other insects besides mealy bugs were also observed in the field, so that further studies on insect transmission must be made before definite conclusions can be reached.

SEED TRANSMISSION

While seed transmission occurs with both lettuce mosaic(12) and cucumber mosaic,(3) this means of infection is not common in the seeds of mosaic-infected nonleguminous hosts. With the mosaics of leguminous plants, however, it is found that infection of the seed by the virus is rather general and common. Kendrick and Gardner(9) reported seed transmission for soy-bean mosaic, McClintock(11) for lima bean, Dickson(2) for garden pea, red clover, alsike clover, and sweet pea, and Reddick and Stewart(13) and Fajardo(6) for the garden bean.

Our results have shown that sincamas mosaic is also transmitted in the seed of the infected sincamas plant. Seeds gathered from five mosaic-infected sincamas plants were divided into two lots. In the first lot the seeds were planted 2 to 3 centimeters apart in a field where sincamas had not been grown before. The second lot of seeds was planted in the same manner but 50 meters away from the first planting. The percentage of plants infected through diseased seeds was recorded after the plants had reached their first, second, or third compound-leaf stage. Of two hundred eighty-nine plants counted in the first planting, and four hundred twenty plants in the second planting, 25 per cent and 26 per cent, respectively, showed infection. In another series, seeds obtained from another source of unknown origin were planted in 8-inch pots in the greenhouse. Of fifty plants examined 5 per cent were infected.

Further experiments were performed, where infected seeds were first surface sterilized with mercuric chloride ($HgCl_2$) (1:1,000) and washed in sterile water. After this treatment the seeds were divided into two lots. In one lot, the seed coats were removed, and in the other lot, they were left intact. The two lots of seeds were then planted separately in 5-inch pots in

the greenhouse. The results show that there is no marked difference in percentage of seed transmission whether the seed coats are removed or not.

The above findings show that the sincamas mosaic is transmitted in the seeds of infected plants; that it is perhaps carried in the embryo of the seed, as in bean mosaic,(6) and that the percentage of seed infection varies in the different lots of seeds obtained from different sources. No evidence was found to show that the viability of the infected seeds is affected by the presence of the virus in them. The vigor of the plant, however, is affected if the infection has its origin in the seed and if the leaf symptoms are severe. It was likewise observed that plants originating from infected seeds do not all develop symptoms at the same time. From 10 to 15 per cent showed symptoms of mosaic later in the development of the plant. This result may in part explain why the increase of mosaic infection in the field cannot be all accounted for as due to insect transmission.

PRESENCE OF VIRUS IN THE FLESHY TAPROOT OF INFECTED PLANTS

In a series of experiments, it was found that the fleshy taproots of mosaic sincamas plants were also infected with the virus. Ten plants of infected seed origin, and five plants from healthy seeds were allowed to grow in the field until their taproots developed to marketable size. In order to avoid field infection the five healthy plants were covered with cloth cages, while the ten mosaic plants were left exposed. After two and one-half months, these plants were pulled up, the tops removed, and the taproots allowed to dry at room temperature for two months. After this period they were all planted separately in large pots. The new shoots, or sprouts, from the ten infected taproots all showed mosaic symptoms, while those from the five healthy taproots remained healthy.

In another series, twenty-five plants secondarily infected in the field were pulled up and the taproots likewise allowed to dry at room temperature for more than two months. They were then replanted in a new field where sincamas had not been grown before. After one and one-half months when notes were made, all showed infection. The symptoms of mosaic were evident on the first few leaves that developed from the new shoot.

Confirmatory of the above experiments, count was made of the plantings of local farmers from their own selected stock

of "mother taproots."[4] It was found that the infection varied from 20 to 100 per cent. This part of the plant, therefore, serves to carry the virus from one season to another, as in the case of beet "stecklings,"[5] or mother sugar beets, where the virus of sugar-beet mosaic overwinters.(14) The relative vigor and viability of the shoot coming from the infected taproot, however, does not seem to be affected by the presence of the virus.

SINCAMAS MOSAIC AND BEAN MOSAIC NOT IDENTICAL

Cross-inoculation studies by the leaf-mutilation method have shown that the virus of sincamas mosaic does not infect the bean, *Phaseolus vulgaris* L. In this connection, earlier studies made by the senior writer on bean mosaic(6) also indicated that bean-mosaic virus is not transmissible to other leguminous or nonleguminous hosts. From these results, it is apparent that sincamas mosaic is different from bean mosaic and probably specific to the sincamas, *Pachyrrhizus erosus* (L.) Urb.

CHEMICAL ANALYSIS

Preparation of samples and methods of analysis.—Unless otherwise stated, only the edible fleshy taproot of the plant was examined for its chemical composition. In the selection of these samples, full-grown mosaic and healthy plants from the same plot, all planted at the same time, were pulled and topped on the same day, and the fleshy roots taken into the laboratory for chemical analysis. A single fleshy taproot from each individual plant was freed from the adhering particles of dirt, sliced into small pieces, and dried at 80° C. in a vacuum oven. The dried tissues were then passed through a drug mill, and the powder thus obtained was analyzed as one separate sample. The dry matter of the sample was obtained by drying freshly cut pieces of the fleshy taproot in a vacuum oven heated at 100° C. until the weight was constant. In the case of the material used for the determination of acidity, the fleshy taproot from each plant, after being cleaned of dirt, was ground in a meat grinder and

[4] In the production of seeds, the fleshy taproots ("mother taproots") of sincamas are pulled up in February or March, hung in bunches, and stored in a shed or house to dry. After three or four months they are planted. From these plantings seeds for the current season are gathered. These seeds are planted in November or December, and the fleshy taproots for commercial purposes are pulled between January and April.

[5] According to Robbins,(15) "stecklings" are beets held overwinter for the production of seed the following season. Prior to digging in the fall, the tops are mowed off, and the "stecklings" are then siloed in earth trenches.

the expressed watery juice immediately analyzed for the acid content.

The reducing sugars, total sugars, dextrin, and starch were determined according to the procedure followed by Link and Tottingham,(10) except that the cuprous oxide resulting from the reduction of Fehling's solution was found by the volumetric thiosulphate method.(4, p. 191) For the crude fiber, pentosans, and total ash the samples were analyzed according to methods of the Association of Official Agricultural Chemists.(4) The total nitrogen (including nitrates) was determined by the usual method.(15) The hydrogen-ion concentration of the juice was obtained by using the potentiometer method, while the "titratable acid" was determined by titrating a given amount of the juice with N/10 potassium hydroxide, using phenolphthalein as indicator.

CHEMICAL COMPOSITION OF MOSAIC AND HEALTHY FLESHY TAPROOTS

In a series of analyses, it was found that there are certain consistent differences in the chemical composition of the healthy and infected fleshy taproots of the plants. As shown in Table 2, the infected taproots contain a comparatively lower percentage of reducing sugar, total sugars, pentosan, and dry matter than the healthy ones. The infected taproots have a considerably higher starch content than the healthy ones. The other carbohydrate constituents show no consistent parallel variations. Except for the starch content our results are in accord with the chemical findings of Brewer, Kendrick, and Gardner(1) on the tomato mosaic and those of Dunlap(5) on the tobacco mosaic. The exceedingly high amount of starch in the taproot of the infected plants cannot be explained until further studies have been made.

In regard to the total nitrogen content of the healthy and infected fleshy taproot, our results show only slight differences. These apparent slight differences in total nitrogen, however, cannot be interpreted as proving that other nitrogenous constituents of the plant are not affected by the virus. No conclusion, therefore, can be arrived at until after the data on the nitrogen partition can be obtained. In this connection, Jodidi, Moulton, and Markley,(7) working on the mosaic disease of spinach, found that the lower nitrogen content of the diseased tissues is one of the striking characteristics of the infected plant.

TABLE 2.—*Chemical composition of the fleshy taproot of healthy and infected sincamas, Pachyrrhizus erosus (L.) Urb.*

[All figures indicate percentages.]

Condition of sample.[a]	Carbohydrates.[b]						Dry matter.	Total ash.[b]	Total nitrogen.[b]	Protein (N x 6.25).
	Reducing sugars.	Total sugars.	Dextrin.	Starch.	Pentosans.	Crude fiber.				
Healthy	17.62	43.80	4.96	0.30	2.45	10.60	17.48	3.19	1.73	10.81
Do	20.68	51.02	6.18	0.74	2.79	9.61	16.25	2.39	1.42	8.87
Mosaic	16.80	38.80	6.03	5.11	1.65	6.18	13.95	2.52	1.25	7.81
Do	13.70	37.07	4.97	7.72	1.81	9.32	10.64	2.66	1.52	9.50

[a] Each sample represents a single fleshy taproot from one plant.
[b] Percentages are based on moisture-free samples.

With respect to acidity, it was found that there is a difference in the p_H value and "titratable acid" of the juice of infected and healthy taproots. As shown in Table 3 the infected taproots have higher p_H values, but lower "titratable acid," than the healthy ones.

TABLE 3.—*Acidity of the juice of infected and healthy fleshy taproots.*

Healthy.			Mosaic.		
Sample No.	p_H value.	"Titratable acid" (c.c. N/10 KOH).[a]	Sample No.	p_H value.	"Titratable acid" (c.c. N/10 KOH).[a]
1	7.08	11.20	1	7.74	9.34
2	7.10	11.12	2	7.42	8.40
3	7.12	11.08	3	7.54	8.62
4	7.20	10.85	4	7.67	9.15
Average	7.12	11.06	Average	7.59	8.88

[a] This is expressed by the number of cubic centimeters N/10 potassium hydroxide required to neutralize the acidity in 100 cubic centimeters of juice.

SUGGESTIONS FOR THE CONTROL OF SINCAMAS MOSAIC

The evidence obtained from this investigation, that the disease is perpetuated from year to year through seeds or taproots of infected plants and that insects are generally responsible for field transmission, suggests the following control measures: (*a*) The use of disease-free seeds, (*b*) the testing of seed lots in advance and the planting only of seeds with a low percentage of infection, (*c*) the application of sprays or dusts as insecticides or repellants for the insects, and (*d*) the selection and breeding for disease-resistant varieties.

Since the virus is carried in the seed of the infected sincamas plant, careful selection of healthy plants for seed purposes cannot be overemphasized. Obviously, the selection of healthy "mother taproots" should not be overlooked. Seed lots from unknown sources intended for field planting should be tested in advance and only seeds with a low percentage of infection should be selected for planting.

Since no experiments have been conducted in the use of sprays or dust as insecticides or repellants no recommendation can be offered concerning their efficacy in the control of the disease. The field transmission, however, can be minimized by "rogueing out" infected plants as early as possible, and from time to time thereafter, before insects become numerous.

SUMMARY

1. A mosaic disease of sincamas, *Pachyrrhizus erosus* (L.) Urb., is described and reported for the first time in the Philippine Islands.

2. The disease is very common on cultivated and wild sincamas in nearly all the provinces of Luzon, causing as high as 30 to 100 per cent infection.

3. The virus is systemic, being present in all aërial vegetative parts of mosaic plants, as well as in the seed and in the fleshy taproot.

4. Attempts to transmit the disease through soil, through contact of roots, and through the aërial parts of plants resulted in failure.

5. Artificial transmission by using the leaf-mutilation method of inoculation was successful.

6. Although the mealy bug *Ferrisia virgata* Ckll. is common in the field, our experiments under controlled conditions in the greenhouse have failed to show that this insect transmits the virus from diseased plants to healthy ones.

7. The sincamas mosaic is transmitted through the seed and through the fleshy taproot of infected plants. These parts of the plant, therefore, serve to carry and spread the disease from one locality to another and from year to year.

8. The seedlings originating from infected seeds manifest a wide variation of symptoms. Likewise the appearance of the symptoms in some seedlings is delayed.

9. The relative vitality of the seeds or shoots arising from infected fleshy roots seems to be unaffected by the presence of the virus. The vigor of the plant, however, is affected when the infection occurs early or when it is transmitted through seed.

10. Chemical analysis shows that the infected fleshy taproot has lower percentages of reducing sugars, total sugars, pentosans, and dry matter, but a higher percentage of starch, than the healthy one. The acidity of the juice from fleshy taproots of infected plants is less than that of the juice from healthy ones.

11. The methods of control suggested are: (*a*) Production of mosaic-free seeds by careful selection of healthy plants, (*b*) testing of seed lots in advance and the planting only of seeds that are free or nearly free from infection, (*c*) early "rogueing out" of mosaic plants from time to time, and (*d*) development and use of resistant varieties.

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ILLUSTRATIONS

PLATE 1

VARIATION IN LEAF SYMPTOMS EXHIBITED BY SINCAMAS PLANTS INFECTED BY MOSAIC DISEASE

FIGS. 1 and 3. Leaves with marked mottling and blistering. Note the dark-green puckered areas near the veins and veinlets.
FIG. 2. Leaf with slight mottling but no reduction in size.
4. Leaf of a healthy plant.

PLATE 2

Enlarged photograph of the leaf shown in Plate 1, fig. 1. The dark-green puckered areas and the extensive clearing of the blade are well shown.

PLATE 3

PHOTOGRAPH OF YOUNG PLANTS GROWN FROM HEALTHY AND INFECTED SEEDS

FIG. 1. Healthy seedling.
2. Infected seedling with severe leaf symptoms. Note the arching of the simple young first compound leaves. These leaves are chlorotic and slightly mottled. Associated with these symptoms, the plant is dwarfed.

PLATE 4

EFFECT OF MOSAIC DISEASE ON THE SIZE OF THE FLESHY TAPROOTS

FIG. 1. Fleshy taproot from a healthy plant.
2. Fleshy taproot from a plant infected early, showing severe symptoms on the leaves.

PLATE 5

COMPARATIVE YIELD OF TAPROOTS FROM FIVE MATURE HEALTHY AND FIVE MATURE MOSAIC-DISEASED SINCAMAS PLANTS FROM THE SAME FIELD

FIG. 1. Taproots from healthy plants.
2. Taproots from mosaic infected plants. These plants were infected early in the season. Note the marked reduction in size of the fleshy taproots of mosaic-infected plants as compared with those of the healthy ones.

PLATE 6

THE CELLULOID CYLINDERS AND THE COMMON MEALY BUGS FERRISIA VIRGATA CKLL. USED IN MOSAIC-TRANSMISSION EXPERIMENTS

FIG. 1. Rows of cylinders where experimental plants are protected from incidental infection. The tops are covered with fine muslin cloth, which is tied tightly around the cylinders with a string. When insects are introduced, the cloth cover is removed, and then immediately replaced as soon as the insects are transferred.

FIGS. 2 and 3. The mealy bug *Ferrisia virgata* used in an attempt to transmit the mosaic virus to healthy plants. The bugs are introduced to the experimental plants by means of a camel's-hair brush.

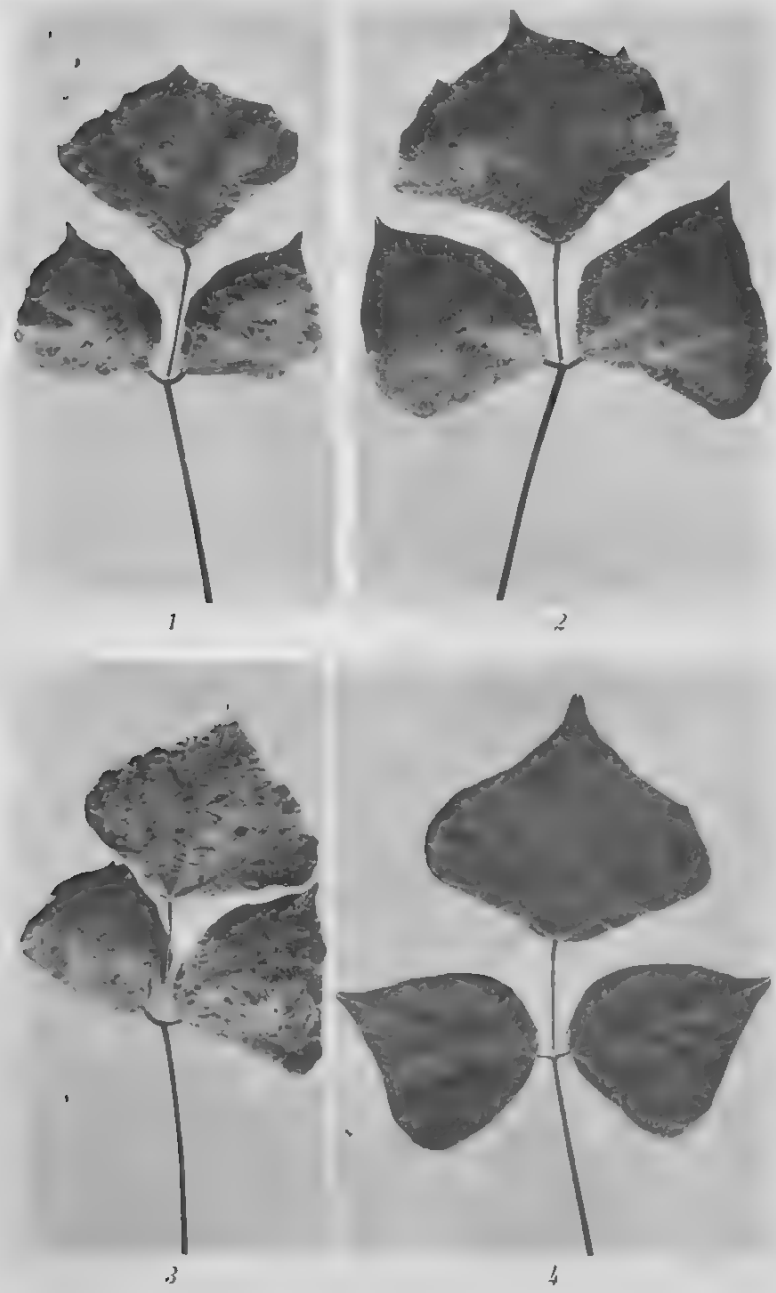

PLATE 1.

PLATE 2.

PLATE 3.

1 2

PLATE 4.

1 2

PLATE 5.

1

2

3

PLATE 6

AN ANATOMICAL STUDY OF THE WOODS OF THE PHILIPPINE MANGROVE SWAMPS[1]

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TWENTY-FOUR PLATES

INTRODUCTION

Mangrove-swamp vegetation is so strikingly unique among plant societies and so wide flung along the tropical coasts of both hemispheres that it has focused the attention of botanists from an early date. Much has been written on the ecology and physiology of the woody plants of this formation, especially of the genera *Rhizophora, Avicennia,* etc., but relatively little is known of the minute structure of their woods. It is the purpose of this article to present in detail the gross and minute anatomical features of the woods of the Philippine mangrove forest; and, in addition, to show what influence, if any, a highly saline and, therefore, "physiologically dry" habitat has had upon the wood structure of such littoral species.

MATERIAL AND METHODS

The material that has served as a basis for this work consisted of a set of wood samples obtained from Mr. Luis J. Reyes, of the Bureau of Forestry, Manila, Philippine Islands. Additional specimens from the Indo-Malayan Region in the wood collections of the New York State College of Forestry served for comparison. With but two exceptions the photographs were taken from the Philippine material; the samples of *Heritiera littoralis* Dry. and *Excoecaria agallocha* L. were too small for low-power photographs, and the illustrations of these woods were prepared from slides loaned by Dr. H. P. Brown from his collection of Indian woods.

The scientific names used in the text are those given in the list which accompanied the set of wood samples, except in two

[1] Contribution from the Department of Wood Technology, New York State College of Forestry, Syracuse.

instances; namely, the name *Rhizophora apiculata* Blume was substituted for *R. candelaria* DC., and *Avicennia marina* Vierh. for *A. officinalis* L.[2] The common and local names were taken for the most part from W. H. Brown.[3] The Engler system has been followed in the sequence of families.

The description of each wood is accompanied by a list of references to the species, and in many cases it has seemed advisable to abbreviate the author's name and the title of his work. The full list of references with complete titles is included in the general bibliography. The anatomical descriptions of the woods by species are divided into two parts; namely, general description of the wood and minute anatomy.

GENERAL DESCRIPTION OF THE WOOD

Under this title are included such characteristics as color, luster, odor, taste, hardness, relative weight and specific gravity, grain, texture, and such anatomical features as can be discerned directly from the wood with the naked eye or a 10x hand lens. Due mention is made of the differences in color between sapwood and heartwood, where the latter is distinct. The publications of Schneider and Foxworthy (see bibliography), where they deal with the descriptions and properties of species included in this investigation, were consulted in order to determine how closely the specimens at hand agreed with the observations of these authors. The specific-gravity data were either taken directly from Foxworthy's Commercial Woods of the Malay Peninsula, or compiled from the wood samples available at Syracuse.

Since much confusion exists in the usage of the terms "grain" and "texture" they are defined here (as accepted in the Department of Wood Technology, New York State College of Forestry) as follows: "Texture" is a measure of the size and the proportional amounts of woody elements, and, therefore, this term is used with such descriptive adjectives as "fine," "coarse," "uniform," etc.; the term "grain," on the other hand, is limited to the arrangement and to the direction or alignment of the elements and, therefore, is qualified by such adjectives as "straight," "interlocked," "curly," etc.

The term "growth ring" is used to designate a "seasonal increment," where the differences in structure are sufficiently pro-

[2] According to Dr. E. D. Merrill, *A. officinalis* L. has been collected only two or three times in the Philippines; *A. marina* Vierh. is very common in the Philippines and throughout Malaysia.

[3] Philip. Bur. Forestry Bull. 22 (1920).

nounced to be discerned with the naked eye. Vessel orifices in the transverse section are designated as "pores," and the expression "vessel lines" is applied to the vessels as they appear along the grain. The following arbitrary classification based on tangential diameters of the larger pores was adapted from Reyes.[4]

Vessels.	Tangential diameter. Microns.
Very small	50–100
Small	100–150
Medium	150–200
Large	200–250
Very large	250+

Parenchyma, unless visible to the naked eye or with a hand lens (10x), is considered as indistinct. When distinct three major types are recognized; namely, paratracheal (about pores); zonate (either paratracheal- or metatracheal-zonate); terminal (at the end of the growth ring). The wood rays are described according to the degree of visibility; as, "plainly visible to the naked eye," "barely visible to the naked eye" or "indistinct without a hand lens," and "barely visible with a hand lens." On the radial section a ray fleck is considered as "high" when it measures over 3 millimeters in height along the grain, "medium high" when it is from 1 to 3 millimeters, and "low" when it is less than 1 millimeter in height.

MINUTE ANATOMY

This subdivision includes the descriptions of the minute anatomical characters of the wood and such features of the individual elements as are discernible with the compound microscope. In this part of the text the terms "vessels" and "vessel groups" are used in preference to "pores" or "clustered pores" since the former describe best these composite elements. The diameters of the vessel orifices were always measured in the tangential plane, and the same procedure was followed in arriving at the diameters of the other elements (fibers, tracheids, and parenchyma cells).

In the description of parenchyma five types of cell arrangement are recognized; namely, "terminal," when the parenchyma cells are restricted to the outer margin of the seasonal ring; "paratracheal," when the parenchyma cells are associated with the vessels; "paratracheal-zonate," when two to many vessels

[4] Philip. Journ. Sci. 22 (1923) 291

are embedded or united by tangential bands of parenchyma; "metatracheal," where the parenchyma cells are more or less indiscriminately distributed throughout the growth ring, either singly or in small groups, but not definitely associated with the vessels; "metatracheal-zonate," a type in which the parenchyma is arranged in one to many seriate, concentric bands extending irrespective of the vessels.

Fibers are designated as "libriform," "semilibriform," or "nonlibriform" depending upon the thickness of the fiber walls, as compared with the diameter of their lumina. A fiber is said to be "libriform" when the thickness of the wall is equal to or is greater than the width of its lumen; "semilibriform" when the thickness of the wall is less than the width of the lumen but equal to at least a quarter of the total diameter of the fiber; and "nonlibriform" when the thickness of the wall is a quarter or less than the total diameter of the fiber. Fibers are described as "fine" when the maximum tangential diameter is less than 24 microns, "medium fine" when the diameter falls between 24 to 40 microns, and "coarse" when the fiber exceeds 40 microns in width.

The spacing of the rays was determined in the transverse section, but in woods possessing only the uniseriate type the number of rays per square millimeter, as seen in the tangential plane, was also taken; they were considered as "numerous" when the count was over 9 per millimeter; "fairly numerous" when 5 to 9 per millimeter; and "not numerous" or "scarce" when less than 5 per millimeter. In compiling data upon the ray size, the largest rays were selected and their height calculated as to number of cells and in microns; in addition the size of what appeared to be the average rays was likewise estimated. The rays were designated as "heterogeneous" when some of the cells were found to be at least twice the height of the others as viewed in radial and tangential sections. The taller cells following the usual custom were termed "upright" and the shorter cells "horizontal." It follows that the "heterogeneous" and "homogeneous" ray types intergrade and hence the decision as to ray composition was often of necessity more or less arbitrary.

In describing wood elements it was frequently found advisable to indicate the plane of section in which the observation was made, and in accordance with this the following abbreviations were adopted: x for the cross or transverse section; t for the tangential; r for the radial section.

The data on "uses" and "working properties" were compiled from different sources, particularly from E. E. Schneider, Commercial Woods of the Philippines: Their Preparation and Uses; and W. H. Brown, Minor Products of Philippine Forests.

ANATOMICAL DESCRIPTION OF WOODS BY SPECIES

APOCYNACEÆ

Trees, shrubs, often twining, rarely perennial herbs, with milky juice, opposite, whorled or rarely alternate, simple leaves, perfect flowers in terminal or axillary, solitary or corymbose cymes, and baccate, drupaceous, or follicular fruits. About 130 genera and over 1,000 species are included in this family, widely distributed throughout the world but chiefly tropical.

The Apocynaceæ are represented in the Philippines by 6 or 7 genera which include several well-known timber species. The most important of these is *Wrightia* R. Br.; this produces the "lanete" wood of the trade which, because of its light color, fine and even texture, and ease of working, is a favorite medium for fine carving. One species of *Cerbera* Linn. occurs in the mangrove forests of the Islands.

Genus CERBERA Linnæus

This genus consists of 4 or 5 species, which are restricted to the tropical tidal forests of Madagascar, Asia, and the Pacific Islands; *C. manghas* Linn. is the sole species in the Philippine flora.

CERBERA MANGHAS Linn. Plate 1.[5]

Common name.—Baraibai.

Local names.—Buto-butó (Surigao, Dinagat); bayag-usá, pandakáki (Camarines); baraibái (Baler); buta-butá (Bataan); bat'áno (Camiguin Island); kúbi (Zambales); ditá (Moro); lipáta (Palawan); panabulón (Negros); dungás (Cotabato).

General description of the wood.—Wood dark grayish brown; heartwood lacking; dull, smooth to the feel, odorless, moderately hard and moderately heavy (specific gravity about 0.6), straight grained, fine textured; finishes smooth. Growth rings absent. Pores not numerous, evenly distributed, arranged in radial rows of two to many and the rows also in radial lines,

[5] *Literature.*—Brown, 1:76; Solereder, 1:53; Ridley, 2:339; Janssonius, 4:593 (*C. odollam*); Koorders and Valeton, 1:85; Hooker, 3:645; Heyne, 2 (1927) 1827; Merrill, 3:330.

very small, not visible to the naked eye, with occasional deposits of lustrous infiltration; vessel lines inconspicuous. Parenchyma in numerous, concentric, very faint, white, unevenly spaced lines. Rays numerous, not visible without a 10x hand lens; ray fleck medium low, inconspicuous, light yellowish brown. Ripple marks absent.

MINUTE ANATOMY

Vessels mostly in radial rows of 2 to 9, with contiguous rays on one and often on both sides, 12 to 16 per square millimeter; orifices more or less angular, the largest 80 to 100 microns in diameter; segments storied with the rays, 300 to 1,000 microns long, with long-attenuate or short and blunt tails; lateral walls 2 to 4 microns thick; perforations simple, horizontal or oblique, circular or elliptical, often located on the lateral walls and not infrequently paired at the end of a given segment; intervessel pits numerous, small (3 to 4 microns in diameter), round, bordered, with narrow orifices; pits leading to contiguous rays numerous to each ray cell, usually in 4 to 8 horizontal rows, simple or bordered, small (3 to 4 microns in diameter), rounded-oblong to elliptical, with broad orifices; tyloses sparse; gummy infiltration not observed.

Parenchyma paratracheal, metatracheal-zonate, and metatracheal, in cambiform rows of 2 to 8 units along the grain; (*a*) paratracheal parenchyma sparse; cells 40 to 60 microns in diameter, 100 to 180 microns long; (*b*) metatracheal-zonate parenchyma in concentric, unevenly spaced, 1- to 3-seriate bands separated by 6 to 40 fibers; cells 12 to 40 microns in diameter, 120 to 220 microns long; (*c*) metatracheal parenchyma sparse; cells similar to those of the *b* parenchyma; globules of light yellow, gummy infiltration frequently present; crystals not observed; starch deposits abundant.

Fibers nonlibriform, arranged in radial rows, nearly square or radially flattened in the transverse section, 30 to 40 microns in diameter, 700 to 1,500 microns long, nongelatinous and gelatinous in alternating bands; walls of nongelatinous fibers 3 to 6 microns in thickness; lignified portion of the wall of the gelatinous fibers 2 to 3 microns thick, the gelatinous layer 6 to 8 microns; interfiber pits mostly confined to the radial walls, simple or bordered, medium large (3 to 4 microns in diameter), round, with narrow, nearly vertical orifices; infiltration not observed.

Rays fine, 8 to 9 per millimeter, separated by 2 to 12 fibers, 1 or 2 (mostly 1) seriate, heterogeneous; the largest 16 to 20 microns wide and 12 plus cells and 500 plus microns high; "upright" cells marginal or interspersed, 40 to 80 microns long, 16 to 20 microns wide, 50 to 85 microns in height; "horizontal" cells 40 to 140 microns long, 8 to 16 microns wide, 25 to 35 microns in height; pits leading to contiguous vessels numerous, in 4 to 8 rows per cell, round, oblong, or elliptical, simple or bordered, with broad orifices; cells occasionally occluded by dark-colored gummy infiltration; crystals not observed; starch deposits abundant.

Remarks.—Interxylary phloëm has been reported in this species, forming a ring or in isolated bundles at the margin of the pith (Solereder 1:55).

Material.—Block 3786 B. F., Palawan.

MELIACEÆ

The mahogany family consists of about 40 genera and over 800 species of trees, shrubs, and woody herbs, widely distributed in the tropical and subtropical regions of both hemispheres; a few species extend into the temperate zones. This family is the source of many valuable timbers, among which are included true mahogany, *Swietenia mahagoni* Jacq.; Spanish cedar, *Cedrela odorata* L.; the toon tree of India, *Cedrela toona* Roxb.; the Australian rosewoods, and most of the "African" mahoganies.

The Meliaceæ are well represented in the Philippines, but most of the species are neither large enough nor sufficiently abundant to be productive as a source of timber. Only four or five are commonly found on the market and of these, "calantas" (*Toona calantas* Merr. and Rolfe), which is practically identical with Spanish cedar, is the best known. *Xylocarpus* Koen. is represented by two or three littoral species that fall within the scope of this report; these produce mahogany-brown woods.

Genus XYLOCARPUS Koenig

This genus is represented by about 12 littoral species in western Africa, 2 or 3 species in tropical America, and 2 in the Philippines, *X. moluccensis* (Lam.) M. Roem. and *X. granatum* Koen.

Key to the species of Xylocarpus Koenig.

1. Heartwood deep wine-red, dull; ripple marks generally indistinct to the naked eye; largest vessels 110 to 120 microns in diameter; fibers nonseptate and septate; rays of two sizes, the smaller 1- or 2-seriate and storied with the vessel segments, the larger 3- to 5-seriate and extending over more than one tier.....*X. moluccensis.*

1. Heartwood reddish brown, with golden luster; ripple marks distinct to the naked eye; largest vessels 120 to 160 microns in diameter; fibers always septate; rays uniform, 3- to 5- (mostly 3-) seriate, storied with the vessel segments .....*X. granatum.*

XYLOCARPUS GRANATUM Koen. Plate 2.[6]

Common name.—Tabigi.

Local names.—Tabigi (Lanao, Cebu, Tayabas, Guimaras, Zamboanga, Negros, Dinagat, Camarines, Masbate, Agusan, Sorsogon, Leyte, Marinduque, Panay, Basilan, Palawan, Samar, Cotabato, Culion); pulit (Basilan); lubanayong (Cagayan); kulimbaning (Culion); tambo-tambó (Zamboanga); nígi (Mindoro, Camarines, Palawan, Zambales, Tayabas); piagáu (Masbate, Zamboanga).

General description of the wood.—Sapwood narrow, whitish; heartwood dark reddish brown with golden luster; smooth to the feel; odorless; moderately hard, moderately heavy (specific gravity 0.65 to 0.80); straight or shallowly interlocked grained, fine textured, finishing smooth. Growth rings distinct. Pores not numerous, evenly distributed, solitary or in short radial groups, medium large and visible to the naked eye; vessel lines distinct, dark colored because of the infiltration. Terminal parenchyma in a fine, distinct line demarking the growth ring. Rays numerous, medium fine, barely visible to the naked eye; ray fleck low to medium high, relatively inconspicuous. Ripple marks present, distinct to the naked eye (*t*), about 26 per centimeter.

MINUTE ANATOMY

Growth rings demarked by a 3- to 5-seriate band of terminal parenchyma.

Vessels solitary or in short radial rows of 2 to 6, surrounded by an uniseriate sheath of parenchyma which is often interrupted by rays contiguous to the vessel, 14 to 16 per square millimeter; orifices round or oblong, the largest 120 to 160 microns in diam-

[6] *Literature.*—Brown, 1:36; Schneider, 138; Foxworthy, Philip. Journ. Sci. 482; Bull. Govern. British North Borneo 12, 36, 48, 58; Malayan Sci. Bull. 113; Foxworthy and Matthews, 5; Kanehira, (1924) 20, 61, 65; Whitford, 2:47; Gamble, (1922) 153; Brandis, 140; Troup, 1:186; Hooker, 1:567; Heyne, 2 (1927) 887; Boulger, 154.

eter; segments storied with the rays, plugged with a black gummy infiltration, 340 to 420 microns long, tailed or truncate; lateral walls 4 to 8 microns thick; perforations simple, round, horizontal or nearly so; intervessel pits very numerous, minute (2 to 3 microns in diameter), round to elliptical; pits leading to contiguous rays numerous to each cell, in 6 to 8 horizontal rows, elliptical to round; tyloses not observed; black gummy infiltration very abundant, occluding many vessel segments.

Parenchyma paratracheal, terminal, and metatracheal, in cambiform rows of 4 to 8 units along the grain which are frequently further divided into locules containing solitary crystals; (*a*) paratracheal parenchyma forming uniseriate sheaths which often encircle the vessel or vessel groups; cells thin walled, 24 to 40 microns in diameter, 60 to 120 microns long; dark brown to black gummy infiltration abundant; crystals present; starch deposits not observed; (*b*) terminal parenchyma in a 3- to 5-seriate band demarking the growth ring; cells thin walled, 24 to 40 microns in diameter, 80 to 100 microns long; dark brown gummy infiltration abundant; crystals present; starch deposits not observed; (*c*) metatracheal parenchyma sparse, the cells solitary (*x*), but otherwise similar to those of the *b* parenchyma.

Fibers nonlibriform to semilibriform, arranged in somewhat indefinite radial rows, septate, rounded in the cross section, 20 to 28 microns in diameter, 750 to 1,500 microns long; lateral walls 4 to 5 microns thick; interfiber pits sparse, simple, minute, slitlike; lumina occasionally plugged with a dark brown gummy infiltration.

Rays 6 to 8 per millimeter, 1- to 4- (mostly 3-) seriate, separated by 3 to 12 fibers, heterogeneous, storied; the largest 60 microns wide, and 30 plus cells and 550 plus microns high; "upright" cells marginal, 40 to 50 microns long, 20 to 30 microns wide, 40 to 60 microns in height; "horizontal" cells round (*t*), 80 to 160 microns long, 12 to 20 microns wide, 20 to 24 microns in height; pits leading to vessels numerous to each ray cell, in 6 to 8 rows, elliptical to round; dark reddish-brown gummy infiltration abundant, occluding most of the cells; crystals present, more numerous in the "upright" cells; starch deposits not observed.

Ripple marks distinct to the naked eye, traceable to the storied vessel segments and rays.

Material.—(1) Block 464 M. P., Manila Market; (2) Forest Experiment Station, Buitenzorg, Java; (3) Kuala Lumpur, Federated Malay States, F. W. Foxworthy, *Xylocarpus* sp.

Uses.—Poles, ties, posts, beams, doors, flooring, interior finish, high-grade furniture and cabinet work. It is considered among the best and most beautiful woods for cabinet work in the Islands.

XYLOCARPUS MOLUCCENSIS (Lam.) M. Roem. Plate 3.[1]

Common name.—Piagau.

Local names.—Piagau (Mindoro, Zamboanga, Negros, Cotabato, Palawan, and Guimaras); lagut-út (Guimaras); tabígi or tibígi (Mindoro and Cotabato); puyugáu (Ticao); sangkúyong (Moro and Jolo); piadak (Palawan).

General description of the wood.—Sapwood light brown; heartwood deep wine-red (darker than that of *X. granatum*); wood dull to somewhat lustrous, smooth to the feel, odorless, moderately hard and moderately heavy (specific gravity 0.65 to 0.80), straight grained, fine textured, working smooth under tools. Growth rings distinct. Pores few, somewhat more numerous at the inception of the ring, arranged in short radial groups, small, barely visible to the naked eye; vessel lines distinct, dark colored because of the presence of black infiltration which occludes many vessel segments. Parenchyma is distinct, concentric lines at the end of the growth rings. Rays medium fine, numerous, barely visible to the naked eye; ray fleck low to medium high, somewhat darker than the background, not very conspicuous. Ripple marks present but often indistinct without a 10x hand lens, about 25 per centimeter.

MINUTE ANATOMY

Growth rings demarked by a 2- or 3-seriate band of parenchyma, and in addition occasionally by a more-porous springwood zone containing crowded vessels.

Vessels solitary or in short radial groups of 2 to 4 (mostly in groups), surrounded by a uniseriate sheath of parenchyma which is often interrupted by rays contiguous to the vessel, frequently many united by concentric, inconspicuous bands of parenchyma, 12 to 15 per square millimeter; orifices round or oval, the largest 110 to 120 microns in diameter; vessel segments often storied with the low rays, 200 to 500 microns long, tailed

[1] *Literature.*—Brown, 1:38; Merrill, 2:358; Schneider, 138; Foxworthy, Malayan Sci. Bull. 113; Philip. Journ. Sci. 482; Bull. Govern. British North Borneo, 12, 36, 48, 58; Foxworthy and Matthews, 6; Whitford, 2:48; Kanehira, (1924) 20; Gamble, 153; Koorders and Valeton, 3:186–196; Brandis, 140; Ridley, 1:414; Moll and Janssonius, 1:206, Solereder, 1:224; Hooker, 1:567.

or truncate; lateral walls 4 to 6 microns thick; perforations simple, round, horizontal; intervessel pits numerous, minute (2 to 3 microns in diameter), crowded, rounded to hexagonal; pits leading to rays numerous to each cell, in 6 to 10 horizontal rows, elliptical; tyloses not observed; dark brown-black gummy infiltration very abundant, occluding many vessels.

Parenchyma paratracheal, paratracheal-zonate, terminal, and metatracheal in cambiform rows of 4 to 8 units along the grain which are often further divided into locules containing solitary crystals; (*a*) paratracheal parenchyma abundant, forming an uniseriate sheath; cells thin walled, 30 to 40 microns in diameter, 40 to 100 microns long; gummy infiltration sparse; crystals numerous; starch deposits present; (*b*) paratracheal-zonate parenchyma in concentric 2- to 3-seriate, concentric bands uniting many vessels; cells thin walled, 24 to 30 microns in diameter, 50 to 90 microns long; inclusions as above; (*c*) terminal parenchyma in a 2- or 3-seriate band; cells similar to those of the *b* parenchyma; (*d*) metatracheal parenchyma sparse; the cells solitary, otherwise similar to those of the *b* parenchyma.

Fibers nonlibriform to semilibriform, indistinctly arranged in radial rows, septate or nonseptate, rounded in the cross section, 20 to 30 microns in diameter, 750 to 1,500 microns long; lateral walls 4 to 6 microns thick; infiltration not observed; interfiber pits sparse, simple, very small, and slitlike.

Rays 5 or 6 per millimeter, separated by 3 to 12 fibers, heterogeneous, of two sizes: (*a*) small rays storied with the vessel segments, 1- or 2-seriate, 10 to 28 microns wide, 10 plus cells and 350 plus microns high: (*b*) large rays extending over more than one tier, 3- to 5-seriate, 60 plus microns wider, 30 plus cells and 850 plus microns high; "upright" cells marginal or interspersed, 40 to 60 microns long, 20 to 30 microns wide, 50 to 60 microns high; "horizontal" cells round (*t*), 80 to 120 microns long, 12 to 29 microns wide, 12 to 30 microns high; light brown gummy infiltration abundant; crystals common, more numerous in the "upright" cells; starch deposits sparse.

Ripple marks frequently indistinct without a 10x lens, traceable to storied vessel segments and rays.

Material.—(1) Block 5520 T. S., Tayabas; (2) Kyathnam, Burma.

Uses.—The wood of this species has the same uses as that of *X. granatum.*

EUPHORBIACEÆ

This family consists of more than 200 genera and over 4,000 species of herbs, shrubs, and trees, generally with milky juice which is frequently poisonous. These plants are widely distributed, especially in the Tropics, and are very variable in habitat. Taken as a whole, the Euphorbiaceæ are important as sources of products other than wood, among which the following deserve mention: Rubber, supplied by *Hevea braziliensis* (HBK.) Muell.-Arg., *Manihot glaziovii* Muell.-Arg. and species belonging to other genera; tapioca, from *Manihot utilissima* Pohl; castor oil, from the seeds of *Ricinus communis* L.; and various medicinal products from different genera. The most important timber-producing species is *Buxus sempervirens* Linn., which is the source of the Turkish boxwood of the trade.

In the Philippines this family is represented by many species, nearly all of which are small and hence unimportant as timber producers. Among the exceptions to this rule are *Bischofia javanica* Bl., a large tree with a reddish-brown, vinegar-scented wood, and various species of *Cyclostemon*, *Aleurites*, and *Endospermum*, which produce woods suitable for interior work; the woods of the last two are considered good in the Islands for matches and match-box veneers.

Genus EXCOECARIA Linnæus

This genus is confined to the Tropics of the Old World and consists of about 30 species of glabrous trees or shrubs with acrid, highly poisonous latex. *Excoecaria agallocha* Linn. occurs in the Philippines on firm mud and the sandy margins of mangrove swamps, also in relatively firm spots within the swamp interior.

EXCOECARIA AGALLOCHA Linn. Plate 4.[8]

Common name.—Buta-buta.

Local names.—Bat'áno (Pangasinan and Cagayan); butá (Basilan, Bataan, Mindoro, and Palawan); buta-butá (Bataan and Palawan); lipáta (Palawan, Agusan, and Camarines); lipátang-búhai (Palawan); alipáta (Negros); kulási (Tayabas and Lanao).

General description of the wood.—Heartwood not distinct; wood light grayish brown, dull, smooth to the feel, odorless,

[8] *Literature.*—Brown, 1:40; Merrill, 3:45; Foxworthy, Philip. Journ. Sci. 428, 431, 485; Foxworthy and Matthews, 9; Gamble, (1922) 626; Ridley, 3:314; Kanehira, (1921) 195; Hooker, 5:472.

but is said to produce a pleasant incense odor when burned, light, soft (specific gravity about 0.45), straight grained, fine textured. Growth rings absent. Pores very few, evenly distributed, solitary or in radial rows of 2 to 4, small, invisible without a 10x hand lens; vessel lines indistinct. Parenchyma in numerous, concentric, closely spaced, wavy lines, which are readily visible with a hand lens. Rays numerous, very fine, barely visible with a 10x hand lens; ray fleck low, about the same color as the background, inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Vessels solitary or in short radial rows of 2 to 4, with contiguous rays on one or both sides, often united by narrow concentric lines of parenchyma, 7 to 14 per square millimeter; orifices round to oblong, the largest 70 to 80 microns in diameter; vessel segments 500 to 760 microns long, tailed or truncate; lateral walls 3 to 4 microns thick; perforations simple, round or oblong, horizontal or slightly oblique; intervessel pits numerous, crowded, large (6 to 8 microns in diameter), rounded to hexagonal, with narrow orifices; pits leading to contiguous rays in 2 or 3 horizontal rows per cell, bordered, large (6 to 8 microns in diameter), rounded, oblong or elliptical, with narrow orifices; tyloses sparse; gummy infiltration not observed.

Parenchyma paratracheal and metatracheal-zonate, in cambiform rows of 2 to 6 (mostly 4) units along the grain; (*a*) paratracheal parenchyma sparse, forming an interrupted, uniseriate sheath around the vessels; cells thin walled, 28 to 40 microns in diameter, 100 to 160 microns long; (*b*) metatracheal-zonate parenchyma abundant, in concentric 1- or 2-seriate lines which alternate with wider bands of fibers and form a fine reticulum with the rays; cells thin walled, 20 to 32 microns in diameter, 160 to 240 microns long; gummy infiltration sparse in both types of parenchyma; crystals not observed; starch deposits abundant.

Fibers nonlibriform, aligned in radial rows, forming concentric 4- to 12-seriate bands which alternate with narrow lines of zonate parenchyma, rectangular in cross section, 20 to 26 microns in diameter, 850 to 1,400 microns long; walls 2 to 4 microns thick; intervessel pits numerous on the radial walls, minute, round, simple.

Rays very fine, close, 10 to 13 per millimeter (*x*), 25 to 30 per square millimeter (*t*), forming a fine reticulum with the zonate parenchyma, heterogeneous, the largest 30 microns wide, and 23

plus cells and 850 plus microns high; "upright" cells marginal and interspersed, 40 to 100 microns long, 10 to 30 microns wide, 34 to 60 microns high; "horizontal" cells round (*t*), 10 to 30 microns wide, 20 to 34 microns high; 80 to 160 microns long; pits leading to contiguous vessels in 2 or 3 horizontal rows per cell, large (6 to 8 microns in diameter), round to oblong or elliptical, bordered, with narrow orifices; light brown gummy infiltration occasional; crystals numerous; starch deposits abundant.

Material.—(1) Block 23133 B. F., Lanao; (2) 3779 B. F., Mindoro.

Uses.—Used for some kinds of furniture, toys, and fuel.

BOMBACACEÆ

This family consists of about 20 genera and 150 species of shrubs and trees, chiefly tropical. The arborescent forms are more valuable for their fibrous bark than for their timber. The family is represented in the Philippines by three genera, but only one species, *Ceiba pentandra* (Linn.) Gaertn., the cotton tree, is of any importance; this was introduced originally from tropical America and is now widely cultivated throughout the Islands for its cotton.

Genus CAMPTOSTEMON Martius

This genus is represented in the Philippines by one species, *C. philippinensis* (Vid.) Becc., a small unimportant tree of the mangrove swamps.

CAMPTOSTEMON PHILIPPINENSE (Vid.) Becc. Plate 5.[1]

Common name.—Gapas-gápas.

Local names.—Baluno and dandulit (Zamboanga); bungalon (Tayabas); gapasgapás (Negros, Zamboanga); libáto-putí, nigi-putí (Tayabas).

General description of the wood.—Heartwood lacking; wood pure creamy white, often blackened with sap stain if seasoned in the log, dull, smooth to the feel, odorless, soft to moderately hard, light (specific gravity about 0.5), straight or shallowly interlocked grained, fine textured, finishing smooth under tools. Growth rings absent. Pores not numerous, evenly distributed, solitary or in short radial groups of 2 to 4, very small (the largest barely visible to the naked eye); vessel lines distinct, darker than the background. Parenchyma in numerous, faint,

[1] *Literature.*—Schneider, 151; Foxworthy, Bull. Govern. British North Borneo, 6; Kanehira, (1924) 11.

white, concentric, closely spaced lines. Rays numerous, barely visible with a 10x hand lens; ray fleck low, inconspicuous, about the same color as the background. Ripple marks present, very conspicuous to the naked eye on the tangential and radial surfaces, about 30 per centimeter.

MINUTE ANATOMY

Vessels solitary or in short radial groups of 2 to 4, with a uniseriate sheath of parenchyma which is frequently interrupted by rays contiguous to the vessel, 8 to 13 per square millimeter; orifices round or slightly flattened radially, the largest 90 to 100 microns in diameter; vessel segments storied with cambiform rows of parenchyma, middle portion of fibers, and rays, 250 to 350 microns long, tailed or truncate; lateral walls 4 to 12 microns thick; perforations simple, round or elliptical, horizontal or slightly oblique; intervessel pits numerous, crowded, minute (1 to 3 microns in diameter), round, with broad orifices; pits leading to contiguous rays numerous to each cell, usually in 5 or 6 horizontal rows, small, round, simple or bordered; tyloses sparse; yellowish gummy infiltration present, occasionally plugging vessel segments.

Parenchyma paratracheal and metatracheal-zonate, in cambiform rows of 2 to 4 (mostly 2) units along the grain; (*a*) paratracheal parenchyma abundant, forming a narrow, usually uninterrupted sheath; cells 20 to 40 microns wide, 50 to 100 microns long; (*b*) metatracheal-zonate parenchyma in concentric, evenly spaced, 1- or 2-seriate lines which alternate with wider bands of fibers and form a fine reticulum with the rays; cells 16 to 20 microns wide, 125 to 170 microns long; gummy infiltration not observed in either type of parenchyma; crystals absent; starch deposits wanting.

Fibers fine, nonlibriform, aligned in radial rows, in concentric, 4- to 7-seriate bands which alternate with the lines of zonate parenchyma, short (650 to 850 microns), 12 to 16 microns in diameter, abruptly tapering and the median portion storied with the vessels segments and rays; walls 3 to 4 microns thick; interfiber pits numerous, simple, more abundant on the radial walls, with narrow, slitlike, nearly vertical orifices; infiltration not observed.

Rays very fine, close [12 to 16 per millimeter (x) and 35 to 40 per square millimeter (t)], forming a fine reticulum with the zonate parenchyma, separated by 2 to 5 fibers, 1- or 2- (mostly 1-) seriate, homogeneous or rarely heterogeneous, storied, with

the vessel segments, fibers, and cambiform rows of parenchyma; the largest 16 to 28 microns in width, 12 plus cells and 300 plus microns in height (maximum 15 cells and 350 microns); "horizontal" cells 30 to 80 microns long, 8 to 12 microns wide, 16 to 24 microns high; "upright" cells (where present) marginal, 30 to 50 microns long, 12 to 28 microns wide, 30 to 44 microns high; pits leading to contiguous vessels small (1 to 3 microns in diameter), numerous, usually in 5 or 6 horizontal rows, round, simple or bordered; infiltration, crystals, and starch deposits not observed.

Ripple marks visible to the naked eye, traceable to storied vessel segments, cambiform rows of parenchyma, fibers (expanded middle portion), and rays.

Material.—Block 18762 B. F., Zamboanga.

Uses.—Planks and temporary construction.

STERCULIACEÆ

The cacao family consists of about 50 genera and 750 species of trees, herbs, and a few climbers, widely distributed in the Tropics, a few extra-tropical. The best-known product of this family is cacao (cocoa), which is obtained from the seeds of *Theobroma cacao* Linn.; this small tree was originally indigenous to Brazil and is now widely cultivated in all tropical countries.

Genus HERITIERA Dryander

This genus embraces 6 or 7 tropical species, of which *H. littoralis* Dryand. is found in every province in the Philippines, in places bordering tide water and the inner edge of mangrove swamps.

HERITIERA LITTORALIS Dryand. Plate 6.[10]

Common name.—Duñgon-láte.

Local names.—Dúñgon-láte and dúñgon (Tayabas, Negros, Butuan, Camarines, Masbate, Lanao, Palawan, Zamboanga, Mindoro, Bataan, Cotabato, Zambales, Manila, Misamis, Leyte, Basilan, Surigao, Palaui Island, Sorsogon, Ticao, Guimaras, and Agusan); paunápin (Cagayan); magáyao (Cagayan); palugápig, paliñgapoi, paronápin, paronápoi (Cagayan, Pangasinan, and Zambales); baut (Moro); malarúñgon (Tayabas); pa-

[10] *Literature.*—Brown, 1:42; Merrill, 3:58; 4:25; Schneider, 151; Foxworthy, Philip. Journ. Sci. 500; Malayan Sci. Bull. 92; Bull. Govern. British North Borneo 26; Foxworthy and Matthews, 8; Gamble, (1922) 98; Koorders and Valeton, 2:170–174; Heyne, (1913–1917) 242; 2 (1927) 959, 1069; Whitford, 2:56; Baker, 47.

loñgápui (Ilocano); duñgon-lalao (Tayabas); bárit (Zamboanga); dumón (Cagayan); bayág-kabáyo (Manila).

General description of the wood.—Sapwood 6 to 8 centimeters thick, white to pale reddish; heartwood sharply delineated from the sapwood, dark reddish brown to dark chocolate brown, often with stony deposits in old knots and in heart cracks; wood dull, fairly smooth to the feel; often with a peculiar odor resembling that of old leather; tasteless; hard, heavy (specific gravity approximately 0.80), straight or shallowly interlocked grained, fine textured. Growth rings present but indistinct to the naked eye. Pores sparse, solitary or arranged in radial groups of 2 to 4, medium large, plainly visible to the naked eye, often occluded with reddish gummy or with white chalky deposits; vessel lines distinct because of the abundant reddish or white infiltration. Parenchyma in numerous concentric, very closely spaced lines which are often almost indistinguishable against the background. Rays numerous, medium large and distinct to the naked eye; ray fleck medium high, somewhat darker than the background but relatively inconspicuous. Ripple marks present on the tangential surface, often indistinct without a 10x hand lens, about 40 per centimeter.

MINUTE ANATOMY

Growth rings occasionally delineated by the crowding of the vessels at the beginning of the ring, often obscure at higher magnifications.

Vessels solitary or in short radial groups of 2 to 4, sometimes more crowded at the beginning of the ring, surrounded by a 1- to 3-seriate sheath of parenchyma which is occasionally interrupted by rays contiguous to the vessel, 6 to 10 per square millimeter; orifices round or oval, the largest 200 microns in diameter; vessel segments 250 to 375 microns long, truncate; lateral walls 6 to 8 microns thick; perforations simple, round or elliptical, horizontal or oblique; intervessel pits very numerous, crowded, minute (2 to 3 microns in diameter), round to elliptical; pits leading to contiguous rays similar to the intervessel pits; tyloses not observed; dark reddish gummy infiltration and white chalky deposits very abundant, occluding most of the vessels.

Parenchyma paratracheal and metatracheal-zonate, in cambiform rows of 2 to 8 units along the grain which are often divided further into locules containing solitary crystals, storied with the larger rays; (*a*) paratracheal parenchyma forming a 1- to 3-seriate sheath; cells thin walled, 24 to 40 microns in diameter,

60 to 100 microns in length, usually flattened to conform to the vessel wall; (*b*) metatracheal-zonate parenchyma in numerous, concentric, closely spaced, uniseriate lines which alternate with narrow bands of fibers and form a fine reticulum with the rays; rounded in cross section, thin walled, 20 to 28 microns in diameter, 40 to 100 microns in length; gummy infiltration present in both types of parenchyma, most abundant in that of the *b* type; crystals numerous, starch deposits not observed.

Fibers fine, semilibriform to libriform (mostly the former), not aligned in radial rows, in concentric 2- to 4-seriate bands which alternate with the uniseriate lines of zonate parenchyma, round or oblong in the cross section, 16 to 20 microns in diameter, 1,000 to 2,100 microns long; lateral walls 4 to 6 microns thick; pits simple, sparse, round, infiltration not observed.

Rays 4 or 5 per millimeter, separated by 8 to 10 fibers, forming a fine reticulum with the zonate parenchyma, 1- to 6-seriate, homogeneous or rarely heterogeneous; the larger storied, 70 microns wide, and 50 plus cells and 1,200 plus microns in height; "upright" cells (when present) marginal and interspersed, 20 to 40 microns high, 40 to 210 microns long, 8 to 16 microns wide; "horizontal" cells round or oblong (*t*), 10 to 20 microns high, 100 to 210 microns long, 8 to 16 microns wide; dark reddish gummy infiltration abundant; crystals present; starch deposits not observed.

Ripple marks present, traceable to storied rays (the larger), and cambiform rows of metatracheal parenchyma.

Material.—(1) Block 5391 B. F., Mindoro; (2) Kuala Lumpur, Federated Malay States, F. W. Foxworthy; (3) No. 6016 T. S., Tayabas.

Remarks.—Wood very strong and tough; extremely difficult to saw owing to the fact that the saws heat; excellent for piling and wherever heavy weights, with their accompanying stresses, must be borne.

Uses.—Pilings, posts, foundation sills, ties, and paving blocks; suitable for bridge, wharf, and ship construction; beams, tool handles, and mallets and other wooden tools; recommended for steamed bent work where strength and durability are required.

LYTHRACEÆ

This family consists of 22 genera and about 450 species of herbs, shrubs, and trees, widely distributed throughout the world where plants grow. Three or four genera are of importance in the Indo-Malayan Region as sources of valuable timbers, among

these, *Lagerstroemia* Linn. The wood of *L. speciosa* L. is said to be one of the finest in India. In the Philippines there are several genera and species of this family.

Genus SONNERATIA Linnæus f.

This genus consists of 4 to 6 species of large trees and shrubs, confined to the tidal tropical forests of the Old World. *Sonneratia caseolaris* (Linn.) Engl. and *S. alba* Sm. occur in Philippine mangrove swamps, but only the first is of commercial importance. For generic description of the wood, see the description of each species, as these two woods are very similar in structure.

Key to the species of Sonneratia Linnæus f.

1. Sapwood grayish brown, 3 to 8 centimeters wide; heartwood dark chocolate brown or black in old trees; fibers nonlibriform to semilibriform, 700 to 1,300 microns long; rays uniseriate..... *S. caseolaris.*
1. Heartwood generally not distinguishable; wood grayish brown; fibers nonlibriform, 600 to 1,000 microns in length; rays 1- or 2-seriate. *S. acida.*

SONNERATIA CASEOLARIS (Linn.) Engl. Plate 7.[11]

Common name.—Pagatpát.

Local names.—Pagatpát (Cebu, Camarines, Tayabas, Cagayan, Samar, Agusan, Basilan, Zambales, Cotabato, Palawan, Mindoro, Zamboanga, Panay, Guimaras, Negros, Leyte, Bataan, and Lanao); bunayon (Dinagat); patpát (Butuan); lukabbán, ilukabbán, lukabbáan (Cagayan); pirara and palalan (Cotabato); buñgálon (Masbate).

General description of the wood.—Sapwood grayish brown, 3 to 8 centimeters wide; heartwood dark grayish brown to chocolate brown, or almost black in old trees; wood dull to somewhat lustrous, smooth to the feel, with swampy odor and distinct salty taste, hard, moderately heavy to heavy (specific gravity 0.59 to 0.85), straight or slightly interlocked grained, fine textured, working to a very smooth finish. Growth rings distinct. Pores numerous, evenly distributed, arranged in radial rows of 2 to 4 or occasionally solitary, medium large, barely visible to the naked eye and appearing as numerous white dots, frequently plugged with tyloses; vessel lines inconspicuous; parenchyma

[11] *Literature.*—Brown, 1:46, Schneider, 178; Merrill, 3:138, 139; 4:26; Foxworthy, Bull. Govern. British North Borneo 38; Philip. Journ. Sci. 525; Whitford, 2:81; Kanehira, (1924) 37; Koorders and Valeton, 1:200.

indistinct. Rays very numerous, very fine, barely visible even with a 10x hand lens; ray fleck low, often of the same color as the background, inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Growth rings distinct, with sinuate margins, delineated by a narrow, denser zone, with fewer and smaller vessels, and several rows of radially flattened fibers.

Vessels somewhat smaller toward the end of the seasonal increment, evenly distributed throughout the ring with the exception of the narrow zone demarking its outer margin (fewer), in radial groups of 2 to 4 or rarely solitary, 25 to 30 per square millimeter; orifices round or oval, the largest 120 to 140 microns in diameter; vessel segments 225 to 750 microns long, with short and blunt, or long-attenuate tails; lateral walls 5 to 8 microns thick; perforations simple, round, horizontal or oblique; intervessel pits numerous, crowded, round or oblong, with fairly broad orifices; pits leading to contiguous rays round to oblong, 6 to 12 microns in diameter; tyloses very abundant, completely occluding the majority of the vessels; gummy infiltration sparse.

Parenchyma lacking.

Fibers semilibriform, aligned in radial rows, septate, 24 to 32 microns in diameter, 700 to 1,300 microns long; lateral walls 5 to 7 microns thick; lumina occluded with dark brownish-black infiltration; interfiber pits bordered, rounded or slitlike, with nearly vertical orifices.

Rays very fine, close, 14 to 16 per millimeter (x), 35 to 40 per square millimeter (t), separated by 1 to 4 fibers, uniseriate, up to 20 microns wide, and 20 plus cells and 700 plus microns in height; homogeneous or heterogeneous; "horizontal" cells 60 to 80 microns long, 12 to 20 microns wide, 20 to 30 microns high; "upright" cells (when present) 30 to 60 microns long, 12 to 30 microns wide, and 30 to 50 microns high; pits leading to contiguous vessels round or oblong, 6 to 12 microns in diameter; dark brownish-black gummy infiltration very abundant, occluding the majority of the cells; crystals present; starch deposits not observed.

Material.—13449 B. F., Zamboanga; block from Manila Market.

Uses.—Piles, posts, poles, ties, paving blocks; shipbuilding, bridge and wharf building; heavy construction of all sorts; doors, siding, ceiling, flooring, and interior finish; furniture, cabinet work, and musical instruments.

SONNERATIA ACIDA Linn. f. Plate 8.[12]

Common name.—Pedada.

Local names.—Payar (Pangasinan); palapát, palata, pagatpát, and hikau-hikáuan (Bataan); pagatpát (Manila and Bataan); lukabbán, ilukabbán (Cagayan).

General description of the wood.—Heartwood generally lacking; wood grayish to light brown, dull, very smooth to the feel, odorless, with a distinct salty taste, moderately hard, moderately heavy (specific gravity about 0.7), straight grained, even and fine textured. Growth rings distinct. Pores numerous, evenly distributed, arranged in radial rows of 2 to many or occasionally solitary, medium large, barely visible to the naked eye; vessel lines indistinct. Parenchyma indistinct. Rays numerous, extremely fine, barely visible even with a 10x hand lens; ray fleck low, of the same color as the background and hence inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Growth rings distinct, delineated by an irregular, narrow zone, with fewer and smaller vessels, and several rows of radially flattened fibers.

Vessels somewhat smaller toward the end of the seasonal ring, uniformly distributed with the exception of the narrow zone at the outer margin (fewer), solitary, and in radial groups of 2 to 4 or occasionally in nests of 3 to 6 (mostly in radial groups), with contiguous rays on one or both sides, 30 to 35 per square millimeter; orifices oval, the largest 110 to 130 microns in diameter; vessel segments 350 to 500 microns long, usually with a long-attenuate tail at one end, and short and blunt at the other end; lateral walls 4 to 6 microns thick; perforations simple, round or oblong, horizontal or oblique; intervessel pits numerous, crowded, round, with narrow orifices; pits leading to contiguous rays round, oblong, elliptical, or scalariform, in 2 to 3 horizontal rows per cell; gummy infiltration sparse; tyloses present, often sclerozed.

Parenchyma lacking.

Fibers nonlibriform to semilibriform, arranged in definite radial rows, septate, 24 to 32 microns in diameter, short (500 to 1,000 microns long); lateral walls 4 to 5 microns thick; inter-

[12] *Literature.*—Brown, 1:44; Schneider, 177; Merrill, 3:138; Foxworthy, Philip. Journ. Sci. 524; Foxworthy and Matthews, 8; Whitford, 2:81; Gamble, (1922) 377; Troup, 2:609; Ridley, 1:825; Moll and Janssonius, 3:598; Koorders and Valeton, 1:198; Hooker, 2:580.

fiber pits minute, bordered, round or slitlike, with nearly vertical orifices; dark brown gummy infiltration and crystalline deposits frequent.

Rays very fine, close, 16 to 18 per millimeter (x), and 55 to 60 per square millimeter (t), separated by 1 to 4 fibers, 1- to 2- (mostly 1-) seriate; the largest 35 microns wide, and 20 plus cells and 600 plus microns in height; homogeneous; cells 20 to 80 (mostly 20 to 40) microns long, 8 to 20 microns wide, 20 to 40 microns high; pits leading to contiguous vessels round, oblong, elliptical or scalariform, in 2 to 3 rows per cell; dark brown, gummy infiltration frequent; crystals numerous; starch deposits not observed.

Material.—(1) Block 5521 T. S., Tayabas.

Uses.—Cut only with the mixed firewoods.

RHIZOPHORACEÆ

Trees or shrubs with opposite or rarely alternate, simple, coriaceous leaves, small, perfect flowers in axillary clusters, and fleshy fruits, the seeds of which often germinate while the fruits are still attached to the tree. This family is distributed throughout the tropical and subtropical regions of the world and consists of about 15 genera and 50 species. Two tribes are recognized; namely, the Rhizophoræ which embrace the littoral species, collectively known as mangroves, and the Legnotidæ consisting of upland forms which flourish in regions often far removed from the ocean.

The Rhizophoraceæ produce a number of hard, heavy, fine-textured timbers which are only of local importance and are used mainly for fuel. The chief commercial product is tannin, obtained from the bark (10 to 30 per cent), especially from that of the littoral species; the collection of tan bark and the extraction of tannin are important industries in the Philippines and in other tropical countries.

In the Philippines the Legnotidæ are represented by the genus *Carallia* Roxb.; and the Rhizophoræ by the genera *Bruguiera* Lam., *Ceriops* Arn., and *Rhizophora* Linn., various species of which often grow in almost pure stands and comprise the bulk of the mangrove swamp.

The woods of the Rhizophoræ are featured as follows: Yellowish to orange-red or dark brown, with or without heartwood; dull to somewhat lustrous; hard; heavy; straight or shallowly interlocked grained and often with conspicuous silvery grain on the radial surface; fine textured. Growth rings absent or scarcely

distinct. Pores solitary or in short radial groups, 12 to 70 per square millimeter, small, barely visible to the naked eye in *Rhizophora* and *Bruguiera* and invisible without a hand lens in *Ceriops*, surrounded by a 1- to 2-seriate sheath of parenchyma; vessel segments tailed, 350 to 1,200 microns long, 50 to 100 microns in diameter, with scalariform perforations and numerous scalariform intervessel pits. Parenchyma paratracheal, paratracheal-zonate, and metatracheal, indistinct at low magnifications. Fibers semilibriform to libriform, aligned in rather indefinite radial rows, often septate, usually plugged with light brown infiltration. Rays numerous, visible to the naked eye, 1- to 8-seriate, high (the largest over 1 centimeter in *Rhizophora*, over 0.8 centimeter in *Bruguiera*, and 0.3 centimeter in *Ceriops*).

Key to the genera of Philippine Rhizophoræ.

1. Wood usually with a conspicuous silvery grain on the radial surface; pores barely visible to the naked eye, 90 to 120 microns in diameter, 12 to 40 per square millimeter; parenchyma paratracheal (very rarely paratracheal-zonate) and metatracheal; fibers septate or nonseptate; largest rays over 5,000 microns in height ..... 2.

1. Wood usually without conspicuous silvery grain on radial surface; pores not visible to the naked eye, 50 to 70 microns in diameter, 20 to 70 per square millimeter; parenchyma paratracheal, paratracheal-zonate, and scattered; fibers nonseptate; largest rays under 3,000 microns in height ..... *Ceriops.*

2. Growth rings absent; pores mostly solitary; fibers 1,200 to 2,200 microns long; rays 1- to 4- (mostly 3-) seriate, the largest up to 10,000 plus microns in height ..... *Rhizophora.*

2. Growth rings present but scarcely distinct; pores mostly in radial groups of 2 to 6 or in small nests; fibers 850 to 1,600 microns long; rays 2- to 8-seriate, the largest up to 8,000 microns in height ..... *Bruguiera.*

Genus BRUGUIERA Lamarck

This genus consists of about seven species of trees and large shrubs which are confined to the mangrove forests of the Old World.

In the Philippines, *Bruguiera* is represented by four species. The wood is characterized as follows: Light brown to orange red, often without distinct heartwood; dull; hard and heavy; straight grained and with conspicuous silvery grain on the radial surface; fine textured. Growth rings usually present but inconspicuous. Pores arranged in short radial groups, 12 to 30 per square millimeter, barely visible to the naked eye, often with a uniseriate sheath of parenchyma; vessel segments tailed, 500 to 1,200 microns long, 90 to 100 microns in diameter, with scalariform perforations and numerous, scalariform intervessel pits. Paren-

chyma paratracheal and metatracheal, generally invisible at low magnifications. Fibers libriform, aligned in radial rows, septate or nonseptate, often plugged with light brown gummy infiltration. Rays numerous, plainly visible to the naked eye, forming conspicuous fleck on the radial surface, 2- to 8-seriate, up to 8,000 plus microns in height, homogeneous or heterogeneous; cells with numerous crystals and copious gummy infiltration.

Key to the species of Bruguiera Lamarck.

1. Wood light brown; largest rays 8,000 plus microns in height; fibers libriform ..... *B. parviflora.*
1. Wood dark reddish brown; largest rays 4,000 plus microns in height; fibers semilibriform to libriform ..... 2.
2. Vessels 12 to 16 per square millimeter ..... *B. sexangula.*
2. Vessels 20 to 40 per square millimeter.
B. conjugata and *B. cylindrica.*

BRUGUIERA CONJUGATA (Linn.) Merr. Plate 9.[12]

Common name.—Busáin.

Local names.—Potótan (Mindoro, Bataan, Tayabas, Negros, Leyte, Zamboanga, Basilan, and Cagayan); busai-ing (Tayabas); bakáu (Tinago Island, Negros, and Zambales); bakáuan (Mindoro); busi-ing (Mindoro); busain or similar forms (Mindoro and Tayabas).

General description of the wood.—Sapwood several centimeters thick; heartwood dark reddish brown, with irregular dark streaks, often lighter and then scarcely distinguishable from the sapwood; wood dull, smooth to the feel, odorless, very hard, heavy (specific gravity 0.74 to 0.94), straight grained, very fine textured. Growth rings present but inconspicuous. Pores evenly distributed, arranged in short radial groups, small, barely visible to the naked eye (appearing as white dots); vessel lines blackish from included infiltration, relatively inconspicuous. Parenchyma indistinct. Rays numerous, visible to the naked eye; ray fleck high, conspicuous. Ripple marks absent.

MINUTE ANATOMY

Vessels solitary, in short radial groups of 2 to 6, or in small nests (mostly in radial groups), with a 1- to 2-seriate sheath of parenchyma which is often interrupted by rays contiguous to the vessel, 28 to 35 per square millimeter; orifices round or oval,

[12] *Literature.*—Brown, 1:52; Foxworthy, Philip. Journ. Sci. 527; Bull. Govern. British North Borneo 32; Malayan Sci. Bull. 133; Whitford, 2:82; Gamble, (1922) 334; Koorders and Valeton, 4:292–295; Heyne, 3 (1913–1917) 351; Troup, 2:503; Moll and Janssonius 3:344; Ridley, 1:695; Hooker, 1:437; Heyne 2 (1927) 1163–1171; Den Berger, 138; Merrill, 3:146.

the largest 100 to 120 microns in diameter; vessel segments 500 to 1,000 microns long, tailed; lateral walls 3 to 5 microns thick; perforations scalariform (8 to 10 bars), oblong, oblique; intervessel pits very numerous, scalariform, extending the full width of the vessel, with very narrow orifices; pits leading to rays, in 2 to 4 rows per cell, oblong or scalariform, several often confluent; tyloses not abundant; black gummy infiltration occasional.

Parenchyma paratracheal and metatracheal, in cambiform rows of 4 to 8 units along the grain; (*a*) paratracheal parenchyma abundant, forming an uninterrupted 1- to 2-seriate sheath; cells medium thick walled, 40 to 160 microns long, 24 to 32 microns in diameter; dark brown gummy infiltration abundant; crystals not observed; starch deposits wanting; (*b*) metatracheal parenchyma sparse, largely restricted to the proximity of the vessels; cells similar to those of the *a* parenchyma.

Fibers libriform, arranged in radial rows, septate or nonseptate, 1,200 to 1,500 microns in diameter, rounded in the cross section, 25 to 32 microns in diameter; lateral walls 6 to 9 microns thick; lumina narrow, plugged with light brown gummy infiltration; interfiber pits simple, rounded, more abundant on the radial walls.

Rays 6 to 8 per millimeter, separated by 2 to 10 fibers, 2- to 6-seriate, homogeneous or heterogeneous; the largest 80 microns wide, and 80 plus cells and 2,500 plus microns in height; "horizontal" cells round or oval (*t*), 100 to 140 microns long, 16 to 28 microns wide, 20 to 35 microns high; "upright" cells (when present) marginal or interspersed, 60 to 120 microns long, 16 to 28 microns wide, 35 to 50 microns high; pits leading to contiguous vessels in 2 to 4 rows per cell, oblong or scalariform, several often confluent; dark reddish brown and light yellow gummy infiltration abundant; crystals numerous; starch deposits not observed.

Material.—Block 13531 B. F., Zamboanga (2 samples).

Uses.—Firewood, constructions, furniture, and piling.

BRUGUIERA CYLINDRICA (Linn.) Blume. Plate 10.[24]

Common name.—Potótan-laláki.

Local names.—Bakáuan (Mindoro); biús (Cotabato); busáin (Mindoro); hiñgáli (Negros); lañgárai (Cotabato); magtoñgóg

[24] *Literature.*—Brown, 1:54; Schneider, 180; Foxworthy, Malayan Sci. Bull. 88; Philip. Journ. Sci. 527; Foxworthy and Matthews, 5; Whitford, 2:82; Gamble, (1922) 334; Koorders and Valeton, 4:298–300; Heyne, 3 (1913–1917) 350; Kanehira, (1921) 108; Troup, 2:504; Moll and Janssonius, 3:343; Ridley, 1:695; Hooker, 2:438; Merrill, 3:147; Den Berger, 138.

(Masbate); potótan and potótan-laláki (Tayabas and Mindoro); tañgal-babáe (Mindoro); kalapínai (La Union); buis (Moro); tañgálan (Mindoro); biuis (Pangasinan); magtañgúd (Masbate); biuas (Bataan).

General description of the wood.—Sapwood whitish to light brown; heartwood dark reddish to grayish brown; wood dull, smooth to the feel, odorless, hard, heavy (specific gravity 0.81 to 0.89), straight grained and with conspicuous silver grain on the radial section, fine textured, working smooth under sharp tools. Growth rings distinct. Pores somewhat crowded at the end of the growth ring, solitary and in short radial groups, small, barely visible to the naked eye (appearing as white dots), often occluded with lustrous infiltration; vessel lines inconspicuous. Parenchyma indistinct. Rays numerous, distinctly visible to the naked eye; ray flecks high, conspicuous. Ripple marks absent.

MINUTE ANATOMY

Growth rings usually marked by a narrow denser zone consisting of thicker-walled fibers and smaller scattered vessels, followed by thinner-walled fibers and several rows of somewhat larger and crowded vessels at the beginning of the next ring.

Vessels solitary, in short radial groups of 2 to 6, or in small nests (mostly in radial groups and nests), larger and more numerous at the inception of the ring, reduced in size and scarce toward the outer margin of the ring, with a uniseriate sheath of parenchyma which is frequently interrupted by rays contiguous to the vessel, 20 to 40 per square millimeter; orifices round, oval, or radially flattened, the largest 90 to 100 microns in diameter; vessel segments 500 to 1,200 microns long, tailed or truncate; lateral walls 3 to 5 microns thick; perforations scalariform with 4 to 8 (usually 5) bars, oblique, oblong; intervessel pits scalariform, extending the full width of the vessel; pits leading to rays in 2 to 4 horizontal rows per cell, scalariform to oblong; tyloses sparse; lustrous infiltration frequent.

Parenchyma paratracheal and metatracheal, in cambiform rows of 4 to 8 units along the grain; (*a*) paratracheal parenchyma forming a 1- or 2- (mostly 1-) seriate sheath; cells medium thick walled, 32 to 40 microns in diameter, 40 to 200 microns long, often occluded with dark brown, gummy infiltration; crystals not observed; starch deposits wanting; (*b*) metatracheal parenchyma sparse, restricted for the most part to the proximity of vessels; cells similar to those of *a* parenchyma.

Fibers semilibriform to libriform, arranged in radial rows, septate or nonseptate, 1,200 to 1,600 microns long, 24 to 28 microns in diameter; lateral walls 4 to 8 microns thick; lumina plugged with light brown, gummy infiltration; interfiber pits simple, rounded, more numerous on the radial walls.

Rays 5 or 6 per millimeter, 2- to 7- (mostly 5-) seriate, separated by 2 to 10 fibers, homogeneous or heterogeneous, largest 120 microns wide, and 100 plus cells and 3,100 plus microns high; small rays 35 to 60 microns wide, and 10 to 30 plus cells and 200 to 600 microns in height; "horizontal" cells rounded or oblong (*t*), 20 to 60 microns long, 12 to 24 microns wide, 20 to 30 microns high; "upright" cells marginal and interspersed, 20 to 60 microns long, 12 to 24 microns wide, 30 to 60 microns high; light yellow and black gummy infiltration frequent; crystals numerous; starch deposits not observed.

Material.—Block 5522 T. S., Tayabas.

Uses.—Firewood and piling.

BRUGUIERA SEXANGULA (Lour.) Poir. Plate 11.[35]

Common name.—Potótan.

Local names.—Potótan or putútan (Tayabas, Zamboanga, Mindoro, Masbate, Misamis, Cotabato, and Palawan); tagása (Bataan); busáin, busáing, etc. (Mindoro, Tayabas, Lanao, and Zamboanga); sagása (Cagayan); alai (Palawan); lagásak (Palaui); bakáuan (Manila); sagásak (Palaui Island); langári (Basilan); potótan-babáe (Palawan and Bataan); bakáuan-laláki; kalabayúan (Bataan); balinsaráyan (Tayabas).

General description of the wood.—Sapwood 2 to 4 centimeters thick; heartwood dark reddish brown, frequently with irregular dark streaks, often lighter and then scarcely distinguishable from the sapwood; wood somewhat lustrous, with smooth feel, odorless, hard, heavy (specific gravity 0.86 to 0.91); straight grained and with conspicuous silver grain on the quarter, fine textured. Growth rings present but inconspicuous. Pores evenly distributed, arranged in short radial rows, small, barely visible to the naked eye (appearing as numerous white dots); vessel lines inconspicuous. Parenchyma indistinct. Rays plain-

[35] *Literature.*—Brown, 1:54; Foxworthy, Philip. Journ. Sci. 527; Bull. Govern. British North Borneo 47; Malayan Sci. Bull. 108; Foxworthy and Matthews, 4; Schneider, 180; Whitford, 2:82; Koorders and Valeton, 4:295, 297; Ridley, 1:695; Heyne, 3 (1913–1917) 350; Heyne, 2 (1927) 1165–1170; Troup, 2:503; Solereder, 1:339–343; Moll and Janssonius, 3:339; Hooker, 2:438; Den Berger, 138; Merrill, 3:147.

ly visible to the naked eye; ray fleck high, conspicuous. Ripple marks absent.

MINUTE ANATOMY

Growth rings ill defined, demarked by a narrow, denser, sinuate zone, consisting of several rows of somewhat radially flattened fibers and devoid of or with few vessels.

Vessels solitary, in short radial rows of 2 to 4, or in small nests (mostly in radial rows), with a 1- or 2-seriate sheath of parenchyma which is often interrupted by rays contiguous to the vessel, 12 to 16 per square millimeter; orifices round or oval, the largest 90 to 100 microns in diameter; vessel segments 350 to 1,000 microns long, tailed or truncate; lateral walls 3 to 5 microns thick; perforations scalariform, with 8 to 10 bars, oblique, oblong; intervessel pits numerous, scalariform, extending the full width of the vessel, with very narrow orifices; pits leading to contiguous rays in 2 or 3 horizontal rows per cell, oblong, elliptical, or scalariform; tyloses not observed; gummy infiltration sparse.

Parenchyma paratracheal and metatracheal, in cambiform rows of 6 to 8 units along the grain; (*a*) paratracheal parenchyma abundant, in a 1- or 2-seriate sheath; cells 40 to 160 microns long, 16 to 36 microns in diameter; gummy infiltration sparse; crystals not observed; starch deposits absent; (*b*) metatracheal parenchyma sparse; cells restricted to the proximity of the vessels, usually solitary, similar to those of the *a* parenchyma.

Fibers semilibriform to libriform, arranged in somewhat indefinite radial rows, septate or nonseptate, 850 to 1,500 microns long, 24 to 30 microns in diameter; lateral walls 4 to 8 microns thick; lumina occasionally plugged with light brown gummy infiltration; interfiber pits simple, round, very numerous on the radial and sparse on the tangential walls.

Rays 7 to 8 per millimeter, separated by 2 to 16 fibers, 2- to 8- (mostly 4- to 6-) seriate, heterogeneous; the largest 120 microns wide, and 80 plus cells and 1,600 plus microns in height; "upright" cells marginal and interspersed (mostly marginal), 30 to 60 microns long, 12 to 24 microns wide, 30 to 40 microns high; "horizontal" cells round (*t*) 30 to 80 microns long, 12 to 24 microns wide, 12 to 30 microns high; pits leading to vessel segments in 2 or 3 horizontal rows per cell, oblong, elliptical, or scalariform; light brown or black gummy infiltration frequent; crystals numerous; starch deposits absent.

Material.—(1) Block 6313 B. F., Bataan; (2) Kuala Lumpur, Federated Malay States, F. W. Foxworthy; (3) 7488 B. F., Palawan.

Uses.[15]—Used principally for firewood; where the tree attains sufficient size, the wood is used for salt-water and foundation piling, mine timbers, house posts, furniture, and cabinet work.

BRUGUIERA PARVIFLORA (Roxb.) W. and A. Plate 12,[16]

Common name.—Lañgárai.

Local names.—Potótan (Tayabas, Cagayan, and Zamboanga); hañgálai or hañgárai (Mindoro, Masbate, Leyte, Iloilo, and Negros); hiñgálai (Polillo); lañgárai or lañgári (Zamboanga, Tayabas, Masbate, Negros, and Zambales); bakáuan-laláki (Batangas); bubutígan, biósan (Samar).

General description of the wood.—Heartwood lacking; wood light brown-yellow (lighter than the other *Bruguiera* species), dull, smooth to the feel, odorless, hard, heavy (specific gravity 0.88 to 0.93), straight grained and with conspicuous silver grain on the quarter, fine textured. Growth rings present but indistinct. Pores evenly distributed, arranged in short radial groups, small (appearing as faint, white dots to the naked eye); vessel lines not distinct. Parenchyma indistinct. Rays numerous, plainly visible to the naked eye; ray fleck high, conspicuous. Ripple marks absent.

MINUTE ANATOMY

Vessels solitary, in radial groups of 2 to 6, or occasionally in small nests (usually in radial groups), with a uniseriate sheath of parenchyma which is often interrupted by rays contiguous to the vessel, 25 to 30 per square millimeter; orifices round or oval, the largest 90 to 100 microns in diameter; vessel segments 500 to 900 microns long, tailed; lateral walls 4 to 6 microns thick; perforations scalariform, oblique, oblong; intervessel pits scalariform, extending the full width of the vessel; pits leading to rays in 2 or 3 rows, oblong to scalariform; tyloses sparse; gummy infiltration not observed.

[16] *Literature.*—Brown, 1:58; Schneider, 181; Foxworthy, Bull. Govern. British North Borneo 25; Philip. Journ. Sci. 527; Malayan Sci. Bull. 106; Foxworthy and Matthews, 5; Whitford, 2:82; Heyne, 3 (1913–1917) 332; Koorders and Valeton, 4:297; Troup, 2:504; Moll and Janssonius, 3:345; Ridley, 1:695; Hooker, 2:438; Heyne, 2 (1927) 1172; Den Berger, 138; Merrill, 3:147.

Parenchyma paratracheal and metatracheal, in cambiform rows of 4 to 12 (mostly 8) units along the grain; (*a*) paratracheal parenchyma forming an uniseriate sheath; cells medium-thick walled, 40 to 80 microns long, 20 to 40 microns in diameter; globules of light brownish gummy infiltration frequent; crystals not observed; starch deposits sparse; (*b*) metatracheal parenchyma sparse, usually restricted to the proximity of the vessels; cells similar to those of the *a* parenchyma.

Fibers libriform, arranged in radial rows, septate or nonseptate, 1,000 to 1,400 microns long, 20 to 30 microns in diameter; lateral walls 7 to 10 microns thick; lumina very small, occasionally plugged with light brown gummy infiltration; interfiber pits round, simple, more abundant on the radial walls.

Rays 6 to 7 per millimeter, separated by 3 to 10 fibers, 2- to 8-seriate, homogeneous or heterogeneous; the largest 140 microns wide, and 200 plus cells and 8,000 plus microns high; "horizontal" cells rounded (*t*), 60 to 90 microns long, 10 to 28 microns wide, 12 to 24 microns high; "upright" cells (when present) 20 to 60 microns long, 10 to 28 microns wide, 24 to 40 microns high; pits leading to vessels in 2 or 3 horizontal rows, oblong to scalariform; light brown or black gummy infiltration frequent; crystals numerous; starch deposits sparse.

Material.—Block 5523 T. S., Tayabas.

Uses.—Firewood and pilings.

Genus CERIOPS Arnott

This genus consists of 7 species of trees and shrubs, all confined to the mangrove forests of the Tropics. *Ceriops tagal* (Perr.) C. B. Rob. and *C. roxburghiana* Arn. occur in the Philippines.

The woods of this genus are characterized as follows: Yellowish to orange-red, without distinct heartwood; dull; hard and heavy; straight grained, very fine textured. Growth rings present but inconspicuous. Pores numerous, evenly distributed, arranged in short radial rows, 25 to 70 per square millimeter, invisible without a 10x hand lens, with a uniseriate sheath of parenchyma, several often united by a 2- to 4-seriate, broken band of zonate parenchyma; vessel segments tailed, 450 to 800 microns long, 50 to 70 microns in diameter with scalariform perforations and numerous scalariform intervessel pits. Parenchyma paratracheal, paratracheal-zonate, and metatracheal, invisible at low magnification. Fibers libriform, fine, arranged

in somewhat indefinite radial rows, nonseptate, plugged with light brownish gummy infiltration. Rays visible to the naked eye (distinctly of two sizes in *C. roxburghiana*), the largest 2,000 plus microns in height, homogeneous or heterogeneous; cells with numerous crystals and copious gummy infiltration.

Key to the species of Ceriops Arnott.

1. Vessels 50 to 70 per square millimeter, the largest 50 to 60 microns in diameter; fibers 16 to 20 microns in diameter; rays 1- to 10-seriate, distinctly of two sizes; large rays plainly visible to the naked eye; small rays fine, 1- to 2-seriate, not visible without a 10x hand lens. *C. roxburghiana.*

1. Vessels 25 to 30 per square millimeter, the largest 60 to 70 microns in diameter; fibers 24 to 28 microns in diameter; rays 1- to 5-seriate, of nearly uniform size, visible to the naked eye..... *C. tagal.*

CERIOPS ROXBURGHIANA Arn. Plate 13.[37]

Common name.—Tañgál.

Local names.—Matañgál (Bataan); tañgál (Tayabas and Camarines); tañgung (Surigao); bakáuan (Bataan and Mindoro); bulubadiáng (Panay); tuñgúg (Negros).

General description of the wood.—Sapwood narrow; heartwood yellowish red to orange-red, changing on exposure to reddish brown, the decoction fluorescent (orange-red); wood dull, smooth to the feel, odorless, hard, heavy (specific gravity 0.88 to 1.07); straight grained, very fine textured, working to a very smooth surface under sharp tools. Growth rings present but inconspicuous. Pores numerous, evenly distributed, very small, invisible without a hand lens, solitary or arranged in short radial groups; vessel lines inconspicuous. Parenchyma in rather poorly defined, concentric lines connecting the vessels. Rays of two sizes, the larger plainly visible to the naked eye, the finer numerous and not visible without a hand lens; ray fleck medium high, of about the same color as, or somewhat lighter than, the background, inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Vessels solitary, in radial groups of 2 to 5, or in small nests (mostly in radial groups), with a uniseriate sheath of paren-

[37] *Literature.*—Brown, 1:60; Foxworthy, Philip. Journ. Sci. 527; Foxworthy and Matthews, 47; Schneider, 181; Koorders and Valeton, 4:287–289; Gamble, 334; Troup, 2:501; Hooker, 2:436; Heyne, 2 (1927) 1167; Den Berger, 140; Merrill, 3:144, 145.

chyma which is frequently interrupted by rays contiguous to the vessel, 2 to many often united by a band of zonate parenchyma, 50 to 70 per square millimeter; orifices round or oblong, the largest 50 to 60 microns in diameter; vessel segments 500 to 800 microns long, tailed; lateral walls 3 to 4 microns thick; perforations scalariform with 6 to 8 bars, elliptical, oblique; intervessel pits scalariform, extending the full width of the vessel, with very narrow orifices; pits leading to rays oblong, elliptical, or scalariform, several often confluent; tyloses present; gummy infiltration not observed.

Parenchyma paratracheal, paratracheal-zonate, and metatracheal, in cambiform rows of 4 to 6 units along the grain; (*a*) paratracheal parenchyma abundant, forming a uniseriate, often uninterrupted sheath; cells medium thick walled, 60 to 120 microns long, 12 to 20 microns in diameter; gummy infiltration present; crystals not observed, starch deposits wanting; (*b*) paratracheal-zonate parenchyma abundant, extending laterally in 2- to 4-seriate, somewhat broken wavy bands which either end blindly or unite 2 to many vessels; similar to those of the *a* parenchyma; (*c*) metatracheal parenchyma sparse, confined to the proximity of the vessels; cells similar to those of the *a* parenchyma.

Fibers fine, libriform, arranged in somewhat indefinite radial lines, nonseptate, 850 to 1,400 microns long, 16 to 20 microns in diameter; lateral walls 7 to 8 microns thick; lumina very small, plugged with light brown gummy infiltration; interfiber pits sparse, rounded, simple.

Rays 7 to 8 per millimeter, separated by 2 to 8 fibers, 1- to 10-seriate, heterogeneous, of two types; (*a*) large rays 3- to 10-seriate and 100 microns in width, up to 80 plus cells and 2,200 plus microns in height; (*b*) small rays 1- to 3-seriate and 4 to 12 microns in width, 1 to 20 cells and 20 to 500 plus microns in height; ray cells very irregular in shape (*t*); "upright" cells marginal and interspersed, 30 to 40 microns long, 4 to 28 microns wide, 40 to 60 microns high; "horizontal" cells 30 to 60 microns long, 4 to 16 microns wide, 16 to 30 microns high; pits leading to vessels oblong, elliptical, or scalariform, several often confluent; globules of light yellow or occasionally black infiltration frequent; crystals numerous; starch deposits not observed.

Material.—Block 5524 T. S., Tayabas.

Uses.—Similar to those of *Ceriops tagal.*

CERIOPS TAGAL (Perr.) C. B. Rob. Plate 14.[18]

Common name.—Tañgál.

Local names.—Tañgál (Tagalog, Bisaya, Zambales, and Zamboanga); tuñgód (Visayan in Negros); tañghál (Mindoro); magtoñgód (Mindoro); tañgál-lalaki (Mindoro); tuñgúd (Jolo); toñgóg (Masbate); tagása (Bataan); pakat (Palawan); tanggui (Culion); tuñgog (Visayan); róñgon (Zambales); rúñgon (Pangasinan).

General description of the wood.—Sapwood narrow; heartwood yellowish to orange-red, changing on exposure to reddish brown; decoction fluorescent (orange-red); wood dull, smooth to the feel, odorless, hard, heavy (specific gravity 0.88 to 1.07), straight grained, very fine textured, working to a very smooth surface under sharp tools. Growth rings present but scarcely distinct. Pores numerous, evenly distributed, solitary and in short radial groups, small, invisible without a hand lens; vessel lines indistinct. Parenchyma forming rather poorly defined, broken, wavy, concentric lines uniting the vessels. Rays numerous, medium fine, visible to the naked eye; ray fleck medium high, somewhat lighter in color than the background, silvery but relatively inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Vessels solitary, in short radial rows of 2 to 4, or in small nests (mostly in radial groups), with a uniseriate sheath of parenchyma, which is frequently interrupted by rays contiguous to the vessel, often united by bands of paratracheal-zonate parenchyma, 25 to 30 per square millimeter; orifices oval, the largest 60 to 70 microns in diameter; vessel segments 450 to 700 microns long, tailed; lateral walls 4 to 5 microns thick; perforations scalariform with 4 to 8 (usually 5) bars, elliptical, oblique; intervessel pits scalariform, usually extending the full width of the vessel, with very narrow orifices; pits leading to rays simple, oblong or scalariform; tyloses abundant; black gummy or light yellow granular infiltrations frequent.

Parenchyma paratracheal, paratracheal-zonate, and metatracheal, in cambiform rows of 6 to 8 units along the grain; (*a*)

[18] *Literature.*—Brown, 1:60; Schneider, 181; Foxworthy, Malayan Sci. Bull. 130; Philip. Journ. Sci. 528; Bull. Govern. British North Borneo 47; Foxworthy and Matthews, 4; Whitford, 2:82; Heyne, 3 (1913–1917) 346–348; Gamble, 333; Koorders and Valeton, 4:284–287; Hooker, 2:436; Merrill, 3:144, 145.

paratracheal parenchyma abundant, in a uniseriate layer which frequently encircles the vessel; cells medium thick walled, 30 to 32 microns wide, 40 to 60 microns long; gummy infiltration present; crystals not observed; starch deposits wanting; (*b*) paratracheal-zonate abundant, extending laterally in short 2- to 4-seriate, broken, wavy bands which either end blindly or unite several vessels; cells similar to those of the *a* parenchyma; (*c*) metatracheal parenchyma sparse, usually confined to the proximity of the vessels; cells similar to those of the *a* parenchyma.

Fibers fine, libriform, aligned in somewhat inconspicuous radial rows, nonseptate, 1,000 to 1,500 microns long, 24 to 28 microns in diameter; lateral walls 8 to 10 microns thick; lumina very small, plugged with light brown infiltration; interfiber pits very sparse, rounded, simple.

Rays 8 to 9 per millimeter, separated by 2 to 12 fibers, 1- to 5-seriate, heterogeneous, up to 70 microns in width, and 80 plus cells and 1,800 plus microns in height (uniseriate rays approximately 16 microns wide and 400 microns in height); "upright" cells marginal and interspersed, 40 to 80 microns long, 16 to 24 microns wide, 30 to 60 microns high; "horizontal" cells oval (*t*), 40 to 100 microns long, 16 to 24 microns wide, 20 to 30 microns high; pits leading to vessels simple, oblong to scalariform; globules of dark brown, gummy infiltration abundant; crystals numerous; starch deposits not observed.

Material.—(1) 444 M. P., Palawan; (2) Kuala Lumpur, Federated Malay States, F. W. Foxworthy.

Uses.—High-grade firewood; pilings, also roof supports, etc.; shipbuilding. A yellowish red dye is obtained from tangal wood and the bark is an important source of tanning materials.

Genus RHIZOPHORA Linnæus

This genus is represented in the Tropics of both hemispheres and consists of eight species, all confined to mangrove swamps. *Rhizophora apiculata* Blume and *R. mucronata* Lam. are found in the Philippines.

The wood of *Rhizophora* is characterized as follows: Sapwood light yellowish brown to grayish brown, 3 to 5 centimeters thick; heartwood orange-red to chocolate-brown; wood dull, hard and heavy, straight or shallowly interlocked grained and frequently with conspicuous silvery grain on the quarter, fine textured. Growth rings wanting. Pores visible to the naked eye, numerous, usually solitary, 20 to 30 per square millimeter,

with a 1- or 2-seriate sheath of parenchyma; vessel segments tailed, 500 to 1,200 microns long, 90 to 100 microns in diameter, with scalariform perforations and numerous, scalariform intervessel pits. Parenchyma paratracheal and metatracheal, invisible at low magnification. Fibers libriform, aligned in somewhat irregular radial rows, septate or nonseptate, often plugged with light brown gummy infiltration. Rays numerous, plainly visible to the naked eye, 1- to 4-seriate, the largest up to 1 plus centimeter in height, homogeneous or heterogeneous; ray cells frequently crystalliferous, many with copious dark brown gummy infiltration.

RHIZOPHORA MUCRONATA Lam. Plate 15.[39]

Common name.—Bacáuan-babáe.

Local names.—Bakáuan (Tagalog); bakháu (Surigao); bakáu (Negros); bakáuang-laláki (Zamboanga); bangkáu (Tagalog in Tayabas).

General description of the wood.—Sapwood light yellowish brown to grayish brown, 3 to 5 centimeters thick; heartwood orange-red; wood dull to somewhat lustrous, smooth to the feel, odorless, hard, heavy (specific gravity 0.77 to 1.13), straight or broadly and shallowly interlocked grained, and with conspicuous silvery grain on the quarter, fine textured. Growth rings absent. Pores fairly numerous, evenly distributed, mostly solitary, small (barely visible to the naked eye as small, white specks); vessel lines distinct, somewhat darker in color than the background, owing to infiltration. Parenchyma indistinct. Rays visible to the naked eye, numerous, straight, ray fleck reddish brown, very high and forming a conspicuous silvery grain against the background of fibrous tissue. Ripple marks absent.

MINUTE ANATOMY

Vessels evenly distributed, mostly solitary, occasionally in radial groups or small nests, encircled by a 1- or 2-seriate sheath

[39] *Literature.*—Brown, 1:68; Schneider, 182; Foxworthy, Philip. Journ. Sci. 526–528; Bull. Govern. British North Borneo 23; Malayan Sci. Bull. 85; Foxworthy and Matthews, 3; Whitford, 2:85; Heyne, 3 (1913–1917) 344, 348, 349; 2 (1927) 1169; Gamble, 335; Koorders and Valeton, 4:278–282; Boulger, 241; Kanehira, (1921) 109; Troup, 2:500; Ridley, 1:693; Hooker, 2:435; Merrill, 3:145; Den Berger, 141; Engler and Prantl, 3, 7 (1898) 44; Holtermann, Der Einfluss des Klimas auf den Bauder Pflanzengewebe (1907), 68, 194; Nördlinger, 4 (1877) 25; Sargent, The Woods of the United States (1885) 46 (as *R. mangle*); Moll and Janssonius, 3:533.

of parenchyma which is frequently interrupted by rays contiguous to the vessel, 20 to 30 per square millimeter; orifices round or oval (mostly round), the largest 90 to 100 microns in diameter; vessel segments 600 to 1,200 microns long, usually with long-attenuate tails; lateral walls 4 to 5 microns thick; perforations scalariform with 5 to 10 (mostly 5) bars, elliptical, oblique; intervessel pits very numerous, scalariform, extending the full width of the vessel, with very narrow orifices; pits leading to rays simple, oblong, elliptical or scalariform, several to each cell; tyloses abundant; dark brown infiltration frequent.

Parenchyma paratracheal and metatracheal, in cambiform rows of 4 to 8 (usually 4) units along the grain; (*a*) paratracheal parenchyma abundant, forming a 1- or 2-seriate uninterrupted sheath; cells thick walled, 36 to 40 microns in diameter, 100 to 180 microns long, occluded with light brown gummy infiltration; crystals not observed; starch grains absent; (*b*) metatracheal parenchyma sparse; cells similar to those of the *a* parenchyma.

Fibers libriform, aligned in somewhat irregular radial rows, septate or nonseptate, 1,200 to 1,800 microns long, hexagonal or angular in the cross section and 20 to 30 microns in diameter; lateral walls 8 to 10 microns thick; lumina very small, plugged with brownish gummy infiltration; interfiber pits small, round, simple, more numerous on the radial walls.

Rays 4 or 5 per millimeter, separated by 6 to 12 fibers, 1- to 4-seriate, homogeneous or heterogeneous, of two types; (*a*) large rays 80 microns wide, and up to 120 plus cells and 6 plus millimeters in height; (*b*) small rays 1,000 to 2,000 microns in height; rays of both types (*t*) frequently aligned in longitudinal rows along the grain; "horizontal" cells medium thick walled, oval (*t*), 80 to 120 microns long, 12 to 20 microns wide, 20 to 30 microns high; "upright" cells 40 to 120 microns long, 12 to 20 microns wide, 30 to 40 microns high; pits leading to vessels oblong, elliptical or scalariform, simple, several to each cell; large globules of a light brown infiltration very frequent in the ray tissue; crystals numerous; starch deposits not observed.

Material.—(1) Block 24408 B. F., Agusan, Philippines; (2) Forest Experiment Station, Buitenzorg, Java.

Uses.—The same uses as *R. apiculata* Blume; according to Schneider it is impossible to say which of these two species furnishes the greater bulk of the timber and firewood brought into the market.

RHIZOPHORA APICULATA Blume. Plate 16.[20]

Common name.—Bakáuan-lalaki.

Local names.—Bakáuan (Tagalog); bakáu (Visayan); bakáuan-babáe (Tagalog, Visayan, Zamboanga); uakátan (Mindoro); bakáuan-laláki (Mindanao); bakad (Zambales); bakháu (Samar, Capiz); bakáu-laláki (Pampanga); bangkáu (Davao).

General description of the wood.—Sapwood light yellow, 3 to 5 centimeters thick, in old trees very sharply differentiated from the heartwood; heartwood orange-red to dark chocolate-brown; wood dull, somewhat rough to the feel, odorless, hard, heavy (specific gravity about 0.9), straight or broadly and shallowly interlocked grained and with conspicuous silvery grain on the quarter, fine textured. Growth rings wanting. Pores fairly numerous, evenly distributed, solitary or in short radial groups, round, small (barely visible to the naked eye as numerous white dots); vessel lines distinct, almost black owing to dark gummy infiltration. Parenchyma indistinct. Rays numerous, visible to the naked eye, straight; ray fleck very high, conspicuous, dark brown, forming a conspicuous silvery grain against the background of fibrous tissue. Ripple marks absent.

MINUTE ANATOMY

Vessels evenly distributed, mostly solitary, occasionally in short radial groups of 2 to 4 or in small nests, with a 1- or 2-seriate sheath of parenchyma which is often interrupted by rays contiguous to the vessel, 20 to 25 per square millimeter; orifices round or oblong (mostly round), the largest 90 to 100 microns in diameter; vessel segments 500 to 1,000 microns long, with long attenuate or less frequently short tails; lateral walls 4 to 8 microns thick; perforations scalariform with 4 to 6 bars, elliptical, oblique; intervessel pits very numerous, scalariform, extending the full width of the vessel, with very narrow orifices; pits leading to rays simple, oblong, elliptical or scalariform; tyloses very abundant; dark brown gummy infiltration frequent.

Parenchyma paratracheal and metatracheal, in cambiform rows of 4 to 8 units along the grain; (*a*) paratracheal parenchyma abundant, forming a 1- or 2-seriate sheath; cells thick walled, 80 to 160 microns long, 30 to 40 microns in diameter,

[20] *Literature.*—Foxworthy, Philip. Journ. Sci. 526–528; Bull. Govern. British North Borneo 23; Foxworthy and Matthews, 3; Schneider, 182; Brown, 1:68; Heyne, 3 (1913–1917) 334, 348, 349; Gamble, 333; Ridley, 1:695 (*R. conjugata*); Hooker, 2:436; Merrill, 3:145.

occluded with light brown gummy infiltration; crystals not observed; starch deposits wanting; (*b*) metatracheal parenchyma sparse; cells similar to those of the *a* parenchyma.

Fibers libriform, aligned in radial rows, septate or nonseptate, 1,300 to 2,200 microns long, rounded or hexagonal in the cross section, 28 to 30 microns in diameter; walls 10 to 12 microns thick; lumina very small, plugged with light brown gummy infiltration; interfiber pits simple, round, more numerous on the radial walls.

Rays 5 to 6 per millimeter, separated by 6 to 10 fibers, 1- to 4-seriate, homogeneous or heterogeneous; the largest 55 microns in width and 150 plus cells and 1 plus centimeter in height; aligned in longitudinal rows along the grain (*t*); "horizontal" cells oval, 60 to 80 microns long, 12 to 16 microns wide, 20 to 30 microns high; "upright" cells 40 to 60 microns long, 12 to 16 microns wide, 30 to 50 microns high; pits leading to vessels simple, oblong, elliptical or scalariform; ray cells filled with dark brown or light yellow infiltration; crystals abundant; starch deposits not observed.

Material.—Blocks 5525 T. S., Tayabas; No. 13533 B. F., Zamboanga.

Uses.—Bakauan is the standard firewood of the Philippine Islands. Where the tree attains sufficient size, the wood is used for salt-water and foundation pilings, mine timbers, house posts, furniture and cabinet work; if properly sawn and carefully seasoned it would make excellent flooring.

Remarks.—Very strong and durable, even when submerged in water, qualities that make it highly desirable for foundations; hard to saw but otherwise not difficult to work.

MYRTACEÆ

The myrtle family consists of about 70 genera and 2,800 species of aromatic evergreen shrubs or trees, which are widely distributed in tropical and subtropical regions. *Eucalyptus* L'Hér., with about 300 species which are mostly Australian, is its most important timber-producing genus. The family is represented in the Philippines by many species; most of them are in the genus *Eugenia* (Linn.) Mich.

Genus OSBORNIA F. Mueller

One littoral species, *O. octodonta* F. Muell., is found in the Philippines; this is a small tree occurring on the margins of mangrove swamps and on sandy beaches.

OSBORNIA OCTODONTA F. Muell. Plate 17.[21]

Common name.—Tawalis.

Local names.—Tuawis (Palawan); tiwayos (Masbate); gunhun (Easilan); maligáng (Polillo); tawalis (Tayabas and Camarines); sagasá (Iloilo); tabáu (Negros); duluk-dúluk and sagasá (Negros); monotbonót (Leyte); kulási (Zamboanga).

General description of the wood.—Sapwood light brown; heartwood dark grayish brown to chocolate-brown; wood somewhat lustrous, smooth to the feel, odorless, hard, heavy (specific gravity about 0.85), narrowly and shallowly interlocked grained, very fine textured, finishing smooth, said to be extremely durable. Growth rings present but indistinct. Pores mostly solitary, very small, invisible to the naked eye, occasionally plugged with lustrous infiltration; vessel lines inconspicuous. Parenchyma indistinct. Rays very numerous, very fine (barely visible with a hand lens); ray fleck very low, about the same color as the background and hence inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Vessels numerous, solitary or occasionally radially or tangentially paired, with contiguous rays on one or both sides, 70 to 90 per square millimeter, orifices elliptical, the largest 50 to 60 microns in diameter; vessel segments 250 to 600 microns long, tailed; lateral walls 3 to 4 microns thick; perforations simple, round, horizontal or occasionally slightly oblique; intervessel pits not numerous, 3 to 5 microns in diameter, round or oblong, with narrow orifices; pits leading to rays simple, 6 to 8 microns in diameter, in 5 or 6 horizontal rows per cell, round, oblong, or elliptical; tyloses sparse; vessels occasionally occluded with light yellow, lustrous infiltration.

Parenchyma paratracheal, metatracheal-zonate, and metatracheal, in cambiform rows of 2 to 5 units along the grain; (*a*) paratracheal parenchyma abundant, never completely encircling the vessel but generally restricted to a group of 2 to many cells on one side; cells medium thick walled (3 to 4 microns), 6 to 24 microns in diameter, 100 to 160 microns long; (*b*) metatracheal-zonate parenchyma abundant, in broken wavy, somewhat rugged 1- to 4-seriate bands; cells similar to those of the *a* parenchyma; (*c*) metatracheal parenchyma abundant, the cells similar to those of the *a* parenchyma; dark gummy infiltration abundant in all types of parenchyma; crystals not observed; starch deposits wanting.

[21] *Literature.*—Brown, 1:72; Merrill, 3:182, 4:89, 130.

Fibers fine, semilibriform to libriform, aligned in radial rows, short (600 to 850 microns), rounded, and 8 to 12 microns in diameter in the cross section; lateral walls 3 to 5 microns thick; lumina plugged with dark-colored infiltration; interfiber pits numerous, round, bordered, 3 to 4 microns in diameter, with narrow, nearly vertical orifices.

Rays very fine, close, 15 to 18 per millimeter, separated by 1 to 5 fibers, 1- or 2- (mostly 1-) seriate, heterogeneous, the largest 12 to 25 microns in width, and 12 plus cells and 350 plus microns in height; "upright" cells marginal for the most part, 20 to 60 microns long, 8 to 16 microns wide, 24 to 40 microns high; "horizontal" cells rounded (*t*), 20 to 60 microns long, 8 to 16 wide, 16 to 20 microns high; pits leading to vessels simple, 6 to 8 microns in diameter, in 5 or 6 horizontal rows per cell, round, oblong, or elliptical; dark-colored gummy infiltration abundant, occluding many cells; crystals not observed; starch grains wanting.

Material.—Block 18816 B. F., Masbate.

COMBRETACEÆ

The white mangrove family consists of about 15 genera and 240 species of trees, shrubs, and herbs, widely distributed throughout the tropical and subtropical regions of the world. Some of the arborescent species are important for their timber, others for their bark, leaves, and fruit which are rich in tannin and dyestuffs. Species of the genera *Terminalia* Linn. and *Lumnitzera* Willd. furnish woods in the Philippines that are of considerable value for general construction, interior finish, and furniture.

Genus LUMNITZERA Willdenow

Two littoral species of *Lumnitzera* occur in the Philippines which produce "tabau wood" in limited quantity. *Lumnitzera* woods are characterized as follows: Yellowish or grayish brown, with a distinct roselike scent when fresh; hard; moderately heavy; fine textured. Pores numerous, evenly distributed (30 to 70 per square millimeter), invisible without a 10x hand lens, encircled by paratracheal parenchyma; vessel segments tailed, 170 to 500 microns long, 60 to 100 microns in diameter, with simple perforations. Parenchyma paratracheal, paratracheal-zonate, and metatracheal, indistinct at low magnifications. Fibers semilibriform to libriform, fine, arranged in radial rows. Rays numerous, very fine (barely visible even with a 10x hand

lens), 1- or 2- (mostly 1-) seriate, up to 14 plus cells in height, homogeneous or heterogeneous.

Key to the species of Lumnitzera Willdenow.

1. Vessels 30 to 45 per square millimeter, the largest 90 to 100 microns in diameter; parenchyma paratracheal and metatracheal; fibers nonlibriform to semilibriform; rays 10 to 14 per millimeter (*x*), 40 to 60 per square millimeter (*t*)..... *L. littorea.*

1. Vessels 60 to 70 per square millimeter, the largest 60 to 70 microns in diameter; parenchyma paratracheal, paratracheal-zonate, metatracheal-zonate, and metatracheal; fibers semilibriform to libriform; rays 14 to 18 per millimeter (*c*), 80 to 100 per square millimeter. *L. racemosa.*

LUMNITZERA LITTOREA (Jack) Voigt. Plate 18.[22]

Common name.—Tabáu.

Local names.—Batíng or baktíng (Tawitawi and Jolo); dalúru-babáe (Tayabas); sagása' (Dinagat); maóro (Surigao); kolasíman (Culion); libáto (Tayabas, Polillo, and Palawan); panting-pantíng (Basilan); kalapíni (Zambales); karifurúg (Cagayan); kulási (Mindoro); bulokbúlok and sala'sá (Occidental Negros); agnáia (Zambales); anilái (Mindoro); papásil (Tayabas); magalolo (Polillo); santíng (Moro and Tawitawi); tabáu (Capiz, Negros, Zamboanga, Sorsogon, and Masbate); dulokdúlok (Masbate).

General description of the wood.—Distinct heartwood wanting; wood grayish brown to yellowish brown with a reddish tinge, becoming lighter on exposure to the air, with a distinct roselike scent when fresh cut, lustrous, smooth to the feel, hard, moderately heavy (specific gravity 0.60 to 0.68), very strong and durable, straight grained, fine textured, surfacing to a silky finish under sharp tools. Growth rings distinct but not prominent, irregular. Pores numerous, evenly distributed, arranged in radial rows of 2 to many, small, invisible without a 10x hand lens, often occluded with white, chalky deposits or lustrous infiltration; vessel lines inconspicuous. Parenchyma indistinct. Rays numerous, very fine (barely visible with a 10x hand lens); ray fleck low, reddish brown, inconspicuous. Ripple marks absent.

[22] *Literature.*—Brown, 1:68; Foxworthy, Philip. Journ. Sci. 529; Bull. Govern. British North Borneo 12, 27; Malayan Sci. Bull. 131; Foxworthy and Matthews, 7; Schneider, 183; Whitford, 2:87; Kanehira, (1924) 31, 62, 69; Koorders and Valeton, 9:31–33; Heyne, 3 (1913–1917) 359; 2 (1927) 1179; Merrill, 3:153; Hooker, 2:451.

MINUTE ANATOMY

Growth rings demarked by a darker zone of denser tissue composed of somewhat radially flattened fibers and crowded, smaller vessels, followed by larger vessels in the next ring.

Vessels mostly in radial rows of 2 to 8, somewhat larger at the beginning of the ring, gradually reduced in size and more crowded toward the outer margin (especially in the narrow zone demarking the seasonal ring), with a 1- or 2-seriate sheath of parenchyma which is frequently interrupted by rays contiguous to the vessel, 30 to 45 vessels per square millimeter; orifices round to oval, the largest 90 to 100 microns in diameter; vessel segments storied, 250 to 525 microns long, with short, blunt, or long-attenuate tails; lateral walls 3 to 5 microns thick; perforations simple, circular, horizontal or slightly oblique; intervessel pits numerous, crowded, 4 to 5 microns in diameter, rounded, with narrow orifices; pits leading to rays numerous to each ray cell, usually in 4 or 5 horizontal rows, simple or bordered, rounded, with narrow orifices; tyloses sparse; white chalky deposits sparse.

Parenchyma paratracheal and metatracheal, in cambiform rows of 2 to 4 units along the grain; (*a*) paratracheal parenchyma abundant, forming a 1- or 2-seriate sheath; cells medium thick walled, 16 to 32 microns in diameter, 40 to 160 microns long; (*b*) metatracheal parenchyma sparse; cells similar to those of the paratracheal parenchyma; dark brown gummy or light yellow granular infiltration very abundant in both types of parenchyma, occluding most of the cells; crystals not observed; starch deposits absent.

Fibers fine, nonlibriform to semilibriform, aligned in radial rows, somewhat thicker walled and radially flattened toward the outer margin of the ring, 20 to 24 microns in diameter, 500 to 1,200 microns long; lateral walls 3 to 5 microns thick; interfiber pits sparse, rounded, simple or bordered, with slitlike, nearly vertical orifices; infiltration not observed.

Rays very fine, close (10 to 14 per millimeter), 40 to 60 per square millimeter (*t*), separated by 1 to 8 fibers, 1- or 2- (mostly 1-) seriate, homogeneous or rarely heterogeneous, the largest 16 to 20 microns in width, and 10 plus cells and 350 plus microns in height; "horizontal" cells 100 to 140 microns long, 12 to 20 microns wide, 16 to 24 microns high; "upright" cells strictly marginal, 40 to 100 microns long, 12 to 20 microns wide, 24 to 36 microns high; pits leading to vessels numerous, usually in 4 or 5 horizontal rows, simple or bordered, rounded, with

narrow orifices; cells occluded with dark gummy, or yellowish granular infiltration; crystals not observed; starch deposits absent.

Material.—Block 5674 T. S., Tayabas.

Remarks.—Wood very strong and extremely durable, and hence much prized for piling, for which purpose it is used with the bark attached; seasons well, keeps its shape even when exposed to severe weather conditions, and easy to work.

Uses.—Piles, poles, house posts, ties, paving blocks, bridges, wharves, in general for heavy construction, ship planking and decks, handles, and cabinet work.

LUMNITZERA RACEMOSA Willd. Plate 19.[23]

Common name.—Kulási'.

Local names.—Tabáu (Iloilo, Tayabas); sulási' (Rizal, Manila); kulási' (Bataan).

General description of the wood.—Heartwood wanting; wood dark grayish brown, somewhat lustrous, smooth to the feel, odorless, hard, medium heavy (specific gravity about 0.65), straight grained, very fine textured, finishing smooth. Growth rings distinct but not prominent. Pores numerous, evenly distributed, arranged in radial lines, small (invisible without a 10x hand lens); vessel lines inconspicuous. Parenchyma indistinct. Rays numerous, very fine (barely visible with a 10x hand lens); ray fleck very low, about the same color as the background and hence inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Growth rings demarked by a narrow darker zone composed of several rows of thicker walled, somewhat radially flattened fibers and quite devoid of vessels, followed by larger vessels in the next ring.

Vessels solitary, in radial groups of 2 to 7, or in small nests, somewhat larger at the beginning of a growth ring, usually solitary and reduced in size toward the outer margin, and generally wanting in the narrow zone demarking the ring, with a 1- or 2-seriate sheath of parenchyma which is often interrupted by rays contiguous to the vessel, 60 to 70 per square millimeter; orifices round or oval, the largest 60 to 70 microns

[23] *Literature.*—Brown, 1:70; Schneider, 183; Foxworthy, Philip. Journ. Sci. 529; Foxworthy and Matthews, 7; Gamble, 348; Koorders and Valeton, 9:33; Whitford, 2:87; Kanehira, (1921) 109; Troup, 2:548; Moll and Janssonius, 3:382; Hooker, 2:452; Lecomte, 165; Merrill, 3:154; Heyne, 2 (1927) 1178.

in diameter; vessel segments storied, 170 to 500 microns long, with long-attenuate tails; lateral walls 4 to 5 microns thick; perforations simple, circular, horizontal or slightly oblique; intervessel pits numerous, crowded, 4 to 5 microns in diameter, round or oblong, with narrow orifices; pits leading to rays in 3 to 5 horizontal rows per cell, bordered, large, 5 to 7 microns in diameter, round or oblong, with narrow orifices; tyloses sparse; white chalky deposits occasionally present.

Parenchyma paratracheal, paratracheal-zonate, metatracheal-zonate, and metatracheal, in cambiform rows of 2 to 4 units along the grain; (*a*) paratracheal parenchyma abundant, forming a 1- or 2-seriate sheath; cells thick walled, 20 to 28 microns in diameter, 80 to 160 microns in length; (*b*) paratracheal-zonate parenchyma abundant, in short, 1- to 3-seriate bands uniting the vessel to proximate rays or occasionally extending across the rays and joining several vessels; (*c*) metatracheal-zonate parenchyma in short, broken, 1- to 3-seriate bands uniting 2 to several rays; cells similar to those of the paratracheal parenchyma; (*d*) metatracheal parenchyma abundant, the cells solitary or in small groups but otherwise similar to those of the paratracheal parenchyma; infiltration absent in all types of parenchyma; crystals not observed; starch deposits very sparse.

Fibers fine, semilibriform to libriform, arranged in radial lines, 18 to 20 microns in diameter, 500 to 1,000 microns long; walls 4 to 6 microns thick; interfiber pits very sparse, minute, round, bordered, with slitlike nearly vertical orifices, dark infiltration sparse.

Rays very fine, close (14 to 18 per millimeter), 80 to 100 per square millimeter (*t*), 1- or 2- (mostly 1-) seriate, homogeneous or occasionally heterogeneous, the largest 30 to 32 microns in width, and up to 14 plus cells and 425 plus microns in height; "horizontal" cells 60 to 80 microns long, 12 to 16 microns wide, 20 to 30 microns high; "upright" cells marginal and interspersed, 40 to 60 microns long, 12 to 16 microns wide, 30 to 40 microns high; pits leading to vessels in 3 to 5 horizontal rows per cell, large, 5 to 7 microns in diameter, round or oblong, bordered, with narrow orifices; dark brown, gummy or light yellow, granular infiltrations copious, occluding most of the ray cells; crystals wanting; starch deposits not observed.

Material.—Block 17334 B. F., Iloilo.

Uses.—Important only for firewood; but sometimes used for house posts.

MYRSINACEÆ

This family includes more than 30 genera and 350 species of trees, shrubs, and a few climbers, confined to tropical and subtropical regions. Taken as a whole the family is not important in timber production.

Genus AEGICERAS Gaertner

This genus is represented in the Philippines by two species of glabrous shrubs or small trees, which border sluggish streams in the interior of mangrove swamps.

The woods of *Aegiceras* are characterized as follows: Dark grayish brown and often oily; moderately hard; moderately heavy; straight grained; fine textured. Pores extremely numerous (80 to 250 per square millimeter), arranged in radial rows of 2 to 8, invisible without a 10x hand lens; vessel segments tailed, short (150 to 250 microns), 40 to 60 microns in diameter, with simple perforations. Parenchyma paratracheal and metatracheal, indistinct at low magnifications. Fibers semilibriform to libriform, fine, aligned in radial rows. Rays plainly visible to the naked eye, 4- to 9-seriate, storied, with many gum cysts occluded with orange gum; ripple marks present, traceable to storied vessel segments, fibers (the expanded middle portion), and rays.

Key to the species of Aegiceras Gaertner.

1. Vessels 100 to 250 per square millimeter, the largest 40 to 50 microns in diameter; fibers nonlibriform to semilibriform; rays 2- to 4-seriate, 30 plus cells high, with 1 to 4 gum cysts (*t*); ripple marks distinct to the naked eyed ..... *A. corniculatum.*

1. Vessels 80 to 120 per square millimeter, the largest 50 to 60 microns in diameter; fibers semilibriform to libriform; rays 4- to 9-seriate, 60 plus cells high, with 1 to 10 gum cysts (*t*); ripple marks not distinct to the naked eye ..... *A. floridum.*

AEGICERAS CORNICULATUM (Linn.) Blanco. Plate 20.[24]

Common name.—Saging-ságing.

Local names.—Timbanbákis, pilápil, pagatpát, pipsík (Bataan); saging-ságing (Capiz, Negros, Lanao, Surigao, and Mindoro); kindug-kindúg, sulásig, tinduk-tindúkan (Tayabas); dumanai (Cagayan); tindok-tindók (Leyte and Tayabas); tin-

[24] *Literature.*—Brown, 1:72; Foxworthy, Malayan Sci. Bull. 131; Philip. Journ. Sci. 538; Foxworthy and Matthews, 9; Gamble, 442; Koorders and Valeton, 5:276–278; Janssonius, 7:347; Troup, 2:637; Ridley, 2:256; The Timbers of the Malayan Penin. 1:212; Hooker, 3:533; Heyne, 2 (1927) 1219; Merrill, 3:255.

dók (Mindoro); tunduk-tundúkan (Polillo); batag-batág (Zambales); bulali (Negros); tayokón (Surigao).

General description of the wood.—Sapwood yellowish with numerous orange dots (gum cysts in the rays); heartwood dark brown, rather oily; wood dull, very smooth to the feel, odorless, moderately heavy (specific gravity about 0.6), straight grained, very fine textured. Growth rings present, inconspicuous. Pores very numerous, minute (not visible without a hand lens), crowded; vessel lines inconspicuous. Parenchyma indistinct. Rays of two kinds; large rays plainly visible to the naked eye, with numerous gum pockets occluded with orange gum; small rays indistinct without a 10x hand lens; ray fleck medium high, very conspicuous owing to the orange infiltration in the gum pockets. Ripple marks present, distinct to the naked eye on both the radial and tangential sections, about 50 per centimeter.

MINUTE ANATOMY

Growth rings demarked by a narrow zone, composed of several rows of radially flattened fibers, with few or no vessels.

Vessels very numerous, crowded, solitary or in radial rows of 2 to 9, 100 to 250 per square millimeter; orifices angular, the largest 40 to 50 microns in diameter; vessel segments storied with the larger rays and the median portion of the fibers, short (150 to 250 microns long), with short, blunt tails or truncate; lateral walls 2 to 3 microns thick; perforations simple, circular, horizontal or slightly oblique; intervessel pits numerous, minute (2 to 3 microns in diameter), crowded, round or elliptical, with broad orifices; pits leading to the rays numerous, in 4 or 5 horizontal rows in each cell, simple, round or oblong; infiltration not observed; tyloses sparse.

Parenchyma paratracheal and metatracheal, in cambiform rows of 2 to 4 (mostly 2) units along the grain; (*a*) paratracheal parenchyma abundant, 1 to 6 cells flanking the vessels or vessel groups but never forming a complete sheath; cells 16 to 24 microns wide, 100 to 120 microns long; (*b*) metatracheal parenchyma sparse; cells similar to those of the paratracheal parenchyma; orange infiltration abundant in both types of parenchyma, occluding many cells; crystals not observed; starch deposits abundant.

Fibers nonlibriform to semilibriform, fine, aligned in radial rows, short (250 to 600 microns), rounded, and 16 to 20 microns in diameter in the cross section, abruptly tapering and the

median portion storied with the vessel segments and large rays; walls 3 to 4 microns thick; interfiber pits fairly numerous, large (5 to 6 microns in diameter), round, bordered, with narrow, oblique orifices; infiltration sparse.

Rays 2 or 3 per millimeter, separated by 2 to 30 fibers, 2- to 4-seriate, homogeneous or heterogeneous, with 1 to 4 gum cysts (*t*), storied with the vessel segments and median portions of the fibers, 80 plus microns in width, and up to 30 plus cells and 700 plus microns in height; 2 to 4 rays are often arranged in a longitudinal row along the grain, and the rays of the series are then separated by 1 to 3 obliquely running fibers, or occasionally by vessels (*t*); ray cells round (*t*); "upright" cells 40 to 80 microns long, 16 to 20 microns wide, 24 to 36 microns high; "horizontal" cells 40 to 100 microns long, 12 to 16 microns wide, 12 to 24 microns high; pits leading to vessels numerous, in 4 or 5 horizontal rows in each cell, simple, round or oblong; orange gummy infiltration abundant in many cells; crystals not observed; starch deposits sparse.

Gum cysts lysigenous, 1 to 4 in each ray (*t*), 2 or 3 often confluent forming a pocket wider than the rest of the ray, about 80 microns in diameter horizontally, 100 microns in height, and approximately 300 microns (*x*) in length along the ray; an orange gum abundant, occluding the cysts.

Ripple marks distinct to the naked eye, traceable to storied vessel segments, fibers (expanded middle portion), and large rays.

Material.—Block 5526 T. S., Tayabas.

AEGICERAS FLORIDUM R. and S. Plate 21.[28]

Common name.—Tinduktindúkan.

General description of the wood.—Sapwood not present in the material examined, the samples consisting entirely of heartwood; wood dark grayish brown, odorless, dull, smooth to the feel, hard, moderately heavy (specific gravity about 0.7), shallowly interlocked grained, very fine textured, and taking a very smooth finish. Growth rings distinct. Pores very numerous, evenly distributed, minute, arranged in radial rows or in small nests; vessel lines inconspicuous. Parenchyma indistinct. Rays plainly visible to the naked eye, with numerous gum cysts, occluded with orange gum; ray fleck high, conspicuous, light yellowish brown or orange-brown, owing to the numerous orange

[28] *Literature.*—Brown, 1:76; Foxworthy, Philip. Journ. Sci. 538; Foxworthy and Matthews, 9; Hooker, 3:533; Merrill, 3:256.

gum cysts. Ripple marks present, indistinct without a hand lens.

MINUTE ANATOMY

Growth rings demarked by a narrow zone of several rows of somewhat radially flattened fibers devoid of vessels, followed occasionally in the preceding ring by a porous belt of crowded vessels.

Vessels very numerous, somewhat crowded at the beginning of the ring, solitary, in short radial groups of 2 to 8, or in small nests, 80 to 120 per square millimeter; orifices somewhat angular, the largest 50 to 60 microns in diameter; vessel segments storied with the fibers, 150 to 250 microns long, truncate or occasionally with short, blunt tails; lateral walls 3 to 4 microns thick; perforations simple, circular, horizontal or occasionally oblique; intervessel pits numerous, minute (2 to 3 microns in diameter), round, with broad orifices; pits leading to rays simple, in 4 or 5 horizontal rows in each cell, rounded, tyloses absent, infiltration not observed.

Parenchyma paratracheal and metatracheal, in cambiform rows of 2 to 4 (mostly 2) units along the grain; (*a*) paratracheal parenchyma abundant, 1 to 6 cells flanking the vessel or vessel group, but never forming a complete sheath; cells 16 to 24 microns wide, 100 to 120 microns long; (*b*) metatracheal parenchyma sparse; cells similar to those of the paratracheal parenchyma; orange infiltration abundant in both types of parenchyma, occluding many of the cells; crystals not observed; starch deposits sparse.

Fibers fine, semilibriform to libriform, aligned in radial rows, short (250 to 600 microns in length), abruptly tapering and the median portion storied with the vessel segments, round and 16 to 24 microns in diameter in the cross section; lateral walls 4 to 8 microns thick; interfiber pits, numerous, large (5 to 6 microns in diameter), round, bordered, with narrow, oblique orifices; infiltration abundant.

Rays 2 or 3 per millimeter, separated by 2 to 30 fibers, 4- to 9-seriate, homogeneous, with 1 to 10 plus gum cysts (*t*), the large often storied with vessel segments and median portion of fibers, up to 170 plus microns wide, and 60 plus cells and 1,200 plus microns in height; 2 to 4 rays are often arranged in longitudinal rows along the grain, and the rays of the series are then separated by 1 to 4 oblique fibers (*t*); ray cells rounded, 40 to 100 microns long, 12 to 20 microns wide, and 8 to 20 microns high; pits leading to rays simple, in 4 or 5 horizontal

rows in each cell, rounded; orange gummy infiltration abundant, occluding many of the cells; crystals present; starch deposits sparse.

Gum cysts lysigenous, 1 to 10 plus in each ray (*t*), several often confluent, forming a pocket which is about 50 microns in horizontal diameter (*t*) and 20 to 50 microns in height, and from 50 to 120 microns in length along the ray (*x*); orange gum abundant, occluding the cysts.

Ripple marks not visible to the naked eye, traceable to storied vessel segments, fibers (expanded middle portion), and large rays.

Material.—Block 3346 T. S., Mindanao.

VERBENACEÆ

The teak family consists of about 70 genera and 750 species of herbs, shrubs, and trees, confined chiefly to the Tropics and Subtropics; there are a few in temperate regions. From the standpoint of timber production teak is the best-known and most-important wood of this family. This is produced by *Tectona grandis* Linn. f., a tree indigenous to India and the Malay Archipelago and grown extensively in plantations.

In the Philippines molave, from *Vitex* spp., is the only wood of any value produced by this family; the teak tree has been planted locally but is of little importance on account of its scarcity.

Genus AVICENNIA Linnæus

Common in tidal swamps in the subtropical and tropical regions of both hemispheres. Three species have been described, two of which occur in the Philippines; of these *A. officinalis* Linn. is too scarce to be of significance. The description of the other species follows.

AVICENNIA MARINA (Forsk.) Vierh. Plate 22.[28]

Common name.—Api-ápi.

Local names.—Miápi (Samar, Leyte, and Masbate); api-ápi (Capiz, Bataan, Davao, Zamboanga, Cotabato, Palawan, and

[28] *Literature.*—Merrill, 3:407; Brown, 1:82 (*A. alba*); Schneider, 206 (*A. alba*); Foxworthy, Philip. Journ. Sci. 553 (*A. officinalis*); Whitford, 2:98 (*A. officinalis*); Heyne, 2 (1927) (*A. alba*); Baker, Australian "Grey Mangrove", Journ. Roy. Soc. N. S. Wales 19 (1915) 269 (*A. officinalis*); Baker, Hardwoods of Austr. and their Econ. 327 (*A. officinalis*); Gamble, 546 (*A. officinalis*); Kanehira, (1921) 165 (*A. officinalis*); (1924) 44 (*A. officinalis*); Janssonius, 3:829–842 (*A. alba*); Ridley, Timbers of Malayan Pen. 1 (1902) 219 (*A. officinalis*); Lecomte, 201–202 (*A. officinalis*).

Mindoro); kalapíni mañgitít (Zambales); buñgálon (Marinduque, Tayabas, Pangasinan, Zambales, Mindoro, Capiz, Iloilo, Camarines, and Negros); kulási (Cotabato); kalapíni (Pangasinan, Bataan, and Zambales); pipisíg or pipisík (Tayabas, Camarines, and Mindoro); piápi (Iloilo, Capiz, Agusan, and Tayabas); liñgóg (Cagayan); piksík (Mindoro).

General description of the wood.—Sapwood and heartwood distinct in very old trees, otherwise not separable; sapwood bluish gray; heartwood gray to olive-brown; wood dull to somewhat lustrous, rough to the feel, odorless, hard, moderately heavy (specific gravity 0.65 to 0.70), straight grained, and the grain very characteristic on the radial surface, owing to the bands of interxylary phloëm, uneven textured (coarse textured in the interxylary phloëm bands and the xylem fine textured). Growth layers abnormal, discontinuous, demarked by light, more or less undulate lines which occasionally branch, preceded by a row of large porelike openings (disorganized soft phloëm), which are plainly visible to the naked eye. Pores confined to the xylem tracts, sparse, evenly distributed, solitary or in short radial groups, barely visible to the naked eye; vessel lines fairly conspicuous owing to their orange infiltration. Porelike openings (phloëm cavities) in a single row bounded without by a tangential band consisting of stone cells and parenchyma, plainly visible to the naked eye, and forming conspicuous vessel-like lines on the radial section. Concentric bands of parenchyma and stone cells numerous, white, frequently forking. Rays numerous, fine, invisible without a 10x hand lens, seemingly interrupted at the layers of interxylary phloëm; ray fleck low, about the same color as the background and hence inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Growth layers distinct, demarked by a tangential band of interxylary phloëm.

Interxylary phloëm in concentric bands; bands more or less undulate, frequently forked, many seriate, composed of thin-walled parenchyma, with numerous scattered stone cells and uniseriate row of large porelike phloëm cavities; this followed by a layer consisting of 2 to 6 rows of stone cells and farther to the outside by 2 to 6 rows of parenchyma. Phloëm cavities (x) with tangential diameter of 170 to 250 microns, about 250 microns in radial diameter, often with remnants of disorganized phloëm tissue in which stone cells are included; parenchyma

cells of the uncrushed phloëm, thin walled rectangular in cross section, 16 to 48 microns in diameter, 20 to 60 microns long (*r*, *t*); gummy infiltration not observed in the parenchyma; crystals abundant; starch deposits sparse; stone cells boxlike, 24 to 40 microns in diameter, 32 to 50 microns long (*r*, *t*); lateral walls 10 to 20 microns thick, lumina very small, 4 to 6 microns in diameter.

Vessels restricted to the xylem tracts, solitary or in short radial rows of 2 to 5, with a 1- to 3-seriate sheath of parenchyma, which is frequently interrupted by rays contiguous to the vessel, 10 to 15 per square millimeter; orifices round or oval, the largest 90 to 100 microns in diameter; vessel segments occasionally plugged with orange gum, short (170 to 350 microns long), with short, blunt tails; lateral walls 3 to 5 microns thick; perforations simple, round, horizontal or oblique; intervessel pits very numerous, round or oblong, 3 to 4 microns in diameter, with broad, round orifices; pits leading to rays numerous to each cell, similar to the intervessel pits; dark orange-brown infiltration frequent; tyloses not observed.

Parenchyma paratracheal and paratracheal-zonate, in cambiform rows of 4 to 6 units along the grain; (*a*) paratracheal parenchyma abundant, forming a 1- to 3-seriate sheath; cells 20 to 32 microns in diameter, 60 to 100 microns long; infiltration absent; crystals not observed; starch deposits wanting; (*b*) paratracheal-zonate parenchyma fairly abundant, in 1- or 2-seriate lines joining the vessels to proximate rays, or occasionally crossing the rays and then uniting several vessels; cells similar to those of the *a* parenchyma.

Fibers fine, semilibriform, not aligned in radial rows, round or oblong, and 20 to 24 microns in diameter in the cross section, 700 to 1,200 microns long; lateral walls 4 to 5 microns thick; interfiber pits sparse, round, simple; infiltration not observed.

Rays fine, close, 10 to 15 per millimeter, separated by 1 to 10 fibers, seemingly interrupted by the layer of stone cells inserted in the middle of the band of interxylary phloëm (*x*), 1- to 5- (mostly 1- or 2-) seriate, heterogeneous; of two kinds; large rays 120 plus microns wide, 30 plus cells and 1,200 plus microns in height; small rays 16 to 35 microns wide, 10 to 30 cells and 100 to 1,200 microns high; "upright" cells marginal or interspersed, 20 to 60 microns long, 16 to 25 microns wide, 30 to 50 microns high; "horizontal" cells 60 to 80 microns long, 16 to 25 microns wide, 12 to 30 microns high; pits leading to vessels nu-

merous to each cell, similar to the intervessel pits; gummy infiltration absent; crystals abundant, often several in the same cell; starch deposits not observed.

Material.—(1) Block 5527 T. S., Tayabas; (2) Block 5223 T. S., Tayabas; (3) Museum plank 222, Masbate; (4) Kuala Lumpur, Federated Malay States, F. W. Foxworthy.

Uses.—Firewood, also is used locally for rice mortars and oil mills; a favorite in some regions for smoking fish.

BIGNONIACEÆ

This family includes about 100 genera and 600 species of trees, climbers, and herbs, which are widely distributed in the tropical and subtropical regions of both hemispheres; there are a few in the temperate zones.

The family Bignoniaceæ is represented in the Philippines by 3 genera in which the species are shrubs or small trees of no importance in the lumber trade.

Genus DOLICHANDRONE Fenzl

This genus consists of 6 to 10 species, confined for the most part to sandy beaches and tidal rivers in tropical Africa, Asia, the Pacific Islands, and Australia. *Dolichandrone spathacea* (Linn. f.) K. Schum. occurs in the mangrove swamps of the Philippine Islands.

DOLICHANDRONE SPATHACEA (Linn. f.) K. Schum. Plate 23.[27]

Common name.—Tuwí.

Local names.—Tañgahás (Mindanao); tewí (Agusan); tiwí (Camiguin); tuwí (Zambales, Bataan, Bulacan, Rizal, Manila, Cavite, Batangas, Camarines, Mindoro).

General description of the wood.—Distinct heartwood wanting; wood creamy white to light brown, dull to somewhat lustrous, smooth to the feel, odorless, soft, light (specific gravity about 0.5), straight or shallowly interlocked grained, fine textured. Growth rings distinct. Pores more numerous and somewhat larger at the beginning of the ring, solitary or arranged in short radial groups of 2 or 3, medium large (barely visible to the naked eye), often jointed by concentric lines of parenchyma; vessel lines light yellow-brown, not very conspicuous. Parenchyma in numerous, white, concentric lines which frequently unite a number of vessels. Rays numerous, very fine,

[27] *Literature.*—Whitford, 2:99; Schneider, 210; Heyne, 2 (1927) 1370; Hooker, 4:378; Janssonius, 8:736; Merrill, 3:444.

barely visible with a 10x hand lens; ray fleck low, about the same color as the background and hence inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Growth rings very conspicuous, demarked by a narrow zone consisting of several rows of radially flattened fibers, and a 2- or 3-seriate concentric band of terminal parenchyma.

Vessels solitary, in short radial groups of 2 or 3, or in small nests, more numerous and larger at the beginning of the ring, with a 1- or 2-seriate sheath of parenchyma which is frequently interrupted by rays contiguous to the vessel, many frequently united by a band of zonate parenchyma, 9 to 12 per square millimeter; orifices round or slightly elongated radially, the largest 120 to 130 microns in diameter; lateral walls 4 to 5 microns thick; vessel segments short (250 to 500 microns long), tailed or truncate; perforations simple or reticulate, round, horizontal; intervessel pits numerous, round, about 4 microns in diameter, with narrow orifices; pits leading to the rays numerous to each cell, in 3 or 4 horizontal rows, bordered, round, with very narrow orifices; tyloses sparse; light orange-brown gummy infiltration frequent.

Parenchyma paratracheal, metatracheal-zonate, and terminal, in cambiform rows of 2 to 6 (mostly 4) units along the grain; (*a*) paratracheal parenchyma abundant, forming a 1- or 2-seriate sheath; cells thin walled, 45 to 50 microns in diameter, 50 to 100 microns long; gummy infiltration not observed; crystals absent; starch deposits occasional; (*b*) metatracheal-zonate parenchyma in numerous, 2- to 5-seriate, concentric bands which unite a number of vessels, and alternate with wider bands of fibrous tissue; cells thin walled, 25 to 35 microns in diameter, 80 to 160 microns long; infiltration as above; (*c*) terminal parenchyma in a 2- or 3-seriate band; cells similar to those of the *b* parenchyma.

Fibers nonlibriform, aligned in radial rows, in 4- to 16-seriate bands which alternate with the narrower bands of zonate parenchyma, rectangular and 20 to 30 microns in diameter in the cross section, short (400 to 1,000 microns); interfiber pits numerous, arranged in pocketlike groups on the radial walls, sparse on the tangential walls, rounded, 2 to 3 microns in diameter; infiltration not observed.

Rays fine, close, 9 or 10 per square millimeter (*x*), 40 to 50 per square millimeter (*t*), separated by 2 to 10 fibers, uniseriate or occasionally biseriate, homogeneous, indistinctly storied; the

largest 20 microns wide, and 16 plus cells and 300 plus microns in height; cells rounded (*t*), 20 to 80 microns long, 12 to 16 microns wide, 16 to 30 microns high; pits leading to the vessels numerous in each ray cell, in 3 or 4 horizontal rows, round, bordered, and with very narrow orifices; gummy infiltration sparse; crystals present; starch deposits not observed.

Material.—Block 5527 T. S., Tayabas.

Uses.—Wooden-shoe soles; handles for kitchen and other household implements.

RUBIACEÆ

The madder family consists of about 350 genera and 4,500 species of trees, shrubs, and herbs, widely distributed throughout the world, but most numerous in the Tropics. Many useful dyes, drugs, and edible products are produced by this group, among which cinchona (the source of quinine) and coffee deserve special mention. The former is obtained from the bark of trees belonging to the genus *Cinchona* Linn.; coffee beans are the seeds of *Coffea arabica* Linn., a small tree extensively cultivated throughout the Tropics. The family is represented in the Philippines by numerous genera, of which *Nauclea* Linn. and *Neonauclea* Merr. include timber trees of sufficient size to be of some importance in timber production.

Genus SCYPHIPHORA Gaertner.

Scyphiphora hydrophyllacea Gaertn. is found in the Islands; it is a small tree or shrub and grows along streams in mangrove swamps.

SCYPHIPHORA HYDROPHYLLACEA Gaertn. f. Plate 24.[88]

Common name.—Nilad.

Local names.—Arinaya (Ilocos Norte); landíng (Culion and Tayabas); tugisak (Cotabato); balasíai (Zambales); kulási' (Tayabas); hanbulali, tabáu (Negros); sagasá (Zamboanga); nílad or nílar (Tagalog).

General description of the wood.—Distinct heartwood wanting; wood dark reddish brown to chocolate brown, dull, smooth to the feel, odorless, hard, heavy (specific gravity about 0.9), straight grained, very fine textured. Growth rings obscure. Pores very numerous, evenly distributed, very small, invisible

[88] *Literature.*—Brown, 1:84; Foxworthy, Philip. Journ. Sci., 562; Foxworthy and Matthews, 7; Ridley, Timbers of Malayan Penin. 210; Koorders and Valeton, 8:125–127; Gamble, 418; Ridley, 2:89; Moll and Janssonius, 6:167; Hooker, 2:125; Heyne, 2 (1927), 1399; Merrill, 3:533.

without a 10x hand lens, plugged with light brown infiltration; vessel lines inconspicuous. Parenchyma indistinct. Rays numerous, very fine, barely visible with a 10x hand lens; ray fleck low, inconspicuous. Ripple marks absent.

MINUTE ANATOMY

Vessels solitary or occasionally in radial groups of 2 or 3, 50 to 80 per square millimeter; orifices round or oval, the largest 50 to 60 microns in diameter; vessel segments plugged with yellowish gummy or granular infiltration, 700 to 800 microns long, with long-attenuate tails; lateral walls 2 to 5 microns thick; perforations simple, round, horizontal or slightly oblique; intervessel pits round, about 4 microns in diameter, with narrow orifices; pits leading to rays numerous to each cell, round; tyloses not observed; light yellow gummy and granular infiltrations abundant.

Parenchyma paratracheal, metatracheal-zonate, and metatracheal, in indistinct cambiform rows of many units along the grain; (*a*) paratracheal parenchyma sparse, restricted to 2 or 3 cells flanking the vessel; cells 16 to 20 microns in diameter, 120 to 170 microns long; small globules of light yellow infiltration frequent, crystals not observed; (*b*) metatracheal-zonate parenchyma abundant, forming numerous, broken, uniseriate lines uniting the vessels; cells similar to those of the *a* parenchyma; metatracheal parenchyma abundant; cells solitary (*x*) but otherwise similar to those of the *a* parenchyma.

Fibers fine, libriform, aligned in rather indistinct radial rows, septate or nonseptate, 80 to 1,200 microns long, 20 to 24 microns in diameter; lateral walls 6 to 8 microns thick; lumina plugged with light brown gummy infiltration; interfiber pits sparse, rounded, simple.

Rays very fine, close, 25 to 30 per millimeter, separated by 2 to 4 fibers, 1- or 2- (mostly 1-) seriate, heterogeneous and the two types of cells further characterized by differences in the color and amount of infiltration; largest rays up to 25 microns wide, and 550 plus microns and 30 plus cells high; "upright" cells marginal, usually in 2 to many rows, 20 to 40 microns wide, 80 to 200 microns high, with numerous, minute globules of dark brown gummy infiltration; "horizontal" cells in 1 to 3 rows, restricted to the body of the rays (*t*), 20 to 30 microns long, 20 to 24 microns wide, 20 to 40 microns high; occluded with light yellow gummy infiltration; crystals not observed.

Material.—Block 5529 T. S., Nilad.

Key to woods based on macroscopic characters.

1. Wood bluish gray; growth rings demarked by a row of very large, porelike cavities resulting from the disintegration of strands of interxylary phloëm ..... *Avicennia marina.*
1. Wood otherwise; interxylary phloëm cavities wanting..... 2.
2. Wood creamy white to light grayish brown..... 3.
2. Wood dark gray-brown to red-brown..... 5.
3. Ripple marks present, conspicuous to the naked eye on both the tangential and radial surfaces, about 30 per centimeter; wood creamy white with black streaks ..... *Camptostemon philippinense.*
3. Ripple marks absent; wood without black streaks..... 4.
4. Growth rings distinct; pores barely visible to the naked eye; wood creamy white to light brown..... *Dolichandrone spathacea.*
4. Growth rings absent; pores not visible to the naked eye; wood light grayish brown ..... *Excoecaria agallocha.*
5. Ripple marks present ..... 6.
5. Ripple marks absent ..... 10.
6. Rays with numerous cysts occluded with orange gum; wood dark grayish brown ..... 7.
6. Rays without gum cysts; wood red-brown or chocolate-brown..... 8.
7. Ripple marks not distinct to the naked eye; pores numerous. *Aegiceras floridum.*
7. Ripple marks distinct to the naked eye; pores extremely numerous. *Aegiceras corniculatum.*
8. Wood with a leatherlike odor; parenchyma in numerous, faint, closely spaced, concentric lines (*x*); pores distinctly visible to the naked eye ..... *Heritiera littoralis.*
8. Wood without a leatherlike odor; parenchyma in distant concentric lines; pores barely visible to the naked eye..... 9.
9. Heartwood deep wine red, dull; ripple marks often indistinct without a 10x hand lens ..... *Xylocarpus moluccensis.*
9. Heartwood red-brown with a golden luster; ripple marks distinct to the naked eye ..... *Xylocarpus granatum.*
10. Rays indistinct to the naked eye..... 11.
10. Rays plainly visible to the naked eye..... 15.
11. Pores sparse; parenchyma in numerous, faint, concentric lines visible with a 10x hand lens..... *Cerbera manghas.*
11. Pores numerous; parenchyma indistinct ..... 12.
12. Wood with a distinct roselike scent, gray-brown with a reddish tinge. *Lumnitzera racemosa.* *Lumnitzera littorea.*
12. Wood without a roselike scent, the reddish tinge wanting..... 13.
13. Wood with a swampy odor and salty taste; pores mostly in radial groups ..... *Sonneratia acida.* *Sonneratia caseolaris.*
13. Wood without swampy odor or salty taste; pores mostly solitary.... 14.
14. Wood red-brown; pores round ..... *Scyphiphora hydrophyllacea.*
14. Wood grayish brown to chocolate-brown; pores elliptical. *Osbornia octodonta.*

15. Wood with a leatherlike odor; parenchyma in numerous, faint, closely spaced, concentric lines; pores distinctly visible to the naked eye. *Heritiera littoralis.*
15. Wood without a leathery odor; concentric lines of parenchyma wanting; pores barely visible or invisible to the naked eye ..... 16.
16. Wood with a conspicuous silvery grain on the quarter; pores barely visible to the naked eye ..... 17.
16. Wood without a conspicuous silvery grain on the quarter; pores invisible to the naked eye ..... 19.
17. Growth rings absent; pores round, mostly solitary. *Rhizophora mucronata.* *Rhizophora apiculata.*
17. Growth rings present; pores elliptical, mostly in radial groups of 2 to 6 ..... 18.
18. Wood light brown ..... *Bruguiera parviflora.*
18. Wood dark reddish brown ..... *Bruguiera sexangula.* *Bruguiera conjugata.* *Bruguiera cylindrica.*
19. Rays of two sizes, the largest distinctly visible to the naked eye, the smaller invisible without a 10x hand lens ..... *Ceriops roxburghiana.*
19. Rays uniform and plainly visible to the naked eye ..... *Ceriops tagal.*

Key to woods based on microscopic characters.

1. Wood with concentric, branching bands of interxylary phloëm. *Avicennia marina.*
1. Wood without interxylary phloëm ..... 2.
2. Vessel perforations and pits scalariform ..... 3.
2. Vessel perforations and pits otherwise ..... 8.
3. Largest vessels 90 to 120 microns in diameter; paratracheal-zonate parenchyma absent; fibers septate; largest rays over 5 millimeters in height ..... 4.
3. Largest vessels 50 to 70 microns in diameter; paratracheal-zonate parenchyma present; fibers nonseptate; largest rays 3 millimeters or less in height ..... 7.
4. Vessels mostly solitary; rays 1- to 4- (mostly 3-) seriate, the largest over 1 centimeter in height ..... *Rhizophora mucronata.*
4. Vessels mostly in radial groups; rays 2- to 8-seriate, the largest less than 1 centimeter in height ..... *Rhizophora apiculata.*
5. Vessels 12 to 16 per square millimeter ..... *Bruguiera sexangula.*
5. Vessels 20 to 40 per square millimeter ..... 6.
6. Largest rays 8 plus millimeters in height; fibers libriform. *Bruguiera parviflora.*
6. Largest rays less than 6 millimeters in height; fibers semilibriform to libriform ..... *Bruguiera conjugata.* *Bruguiera cylindrica.*
7. Rays 1- to 10-seriate; vessels 50 to 70 per square millimeter, the largest 50 to 60 microns in diameter; fibers 16 to 20 microns in diameter. *Ceriops roxburghiana.*
7. Rays 1- to 5-seriate; vessels 25 to 30 per square millimeter; the largest 60 to 70 microns in diameter; fibers 24 to 28 microns in diameter. *Ceriops tagal.*

8. Perforations simple and reticulate..... *Dolichandrone spathacea.*
8. Perforations simple throughout..... 9.
9. Rays storied ..... 10.
9. Rays not storied ..... 15.
10. Rays with numerous gum cysts ..... 11.
10. Rays without gum cysts ..... 12.
11. Rays 2- to 4-seriate, 30 plus cells high; vessels 100 to 250 per square millimeter, the largest 40 to 50 microns in diameter.
Aegiceras corniculatum.
11. Rays 4- to 9-seriate, 60 plus cells high; vessels 20 to 120 per square millimeter, the largest 50 to 60 microns in diameter.
Aegiceras floridum.
12. Rays uniseriate; largest vessels 90 to 100 microns in diameter.
Camptostemon philippinense.
12. Rays 1- to 6-seriate; largest vessels 110 to 200 microns in diameter.... 13.
13. Metatracheal-zonate parenchyma in uniseriate, concentric, close lines, separated by 1- to 4-seriate bands of fibers; largest vessels 200 microns in diameter; fibers nonseptate..... *Heritiera littoralis.*
13. Metatracheal-zonate parenchyma in 2- to 5-seriate, concentric, distant bands; largest vessels 110 to 160 microns in diameter; fibers septate or nonseptate ..... 14.
14. Rays of two sizes, the smaller 1- or 2-seriate and storied with the vessel segments, the larger 3- to 5-seriate; largest vessels 110 to 120 microns in diameter; fibers septate or nonseptate.
Xylocarpus moluccensis.
14. Rays of nearly uniform size 3- to 5- (mostly 3-) seriate; largest vessels 120 to 160 microns in diameter; fibers always septate.
Xylocarpus granatum.
15. Rays 1- to 9-seriate..... 16.
15. Rays 1- or 2-seriate..... 18.
16. Rays with gum cysts; parenchyma paratracheal and metatracheal; vessels 80 to 250 per square millimeter..... 17.
16. Rays without gum cysts; parenchyma paratracheal and metatracheal-zonate; vessels 6 to 10 per square millimeter..... *Heritiera littoralis.*
17. Rays 2- to 4-seriate, 30 plus cells high; vessels 200 to 250 per square millimeter, the largest 40 to 50 microns in diameter.
Aegiceras corniculatum.
17. Rays 4- to 9-seriate, 60 plus cells high; vessels 80 to 120 per square millimeter, the largest 50 to 60 microns in diameter.
Aegiceras floridum.
18. Parenchyma wanting; largest vessels 110 to 140 microns in diameter; fibers septate ..... 19.
18. Parenchyma present; largest vessels 50 to 100 microns in diameter; fibers septate or nonseptate ..... 20.
19. Rays uniseriate; fibers nonlibriform to semilibriform.
Sonneratia caseolaris.
19. Rays 1- to 2-seriate; fibers nonlibriform..... *Sonneratia acida.*
20. Vessels 7 to 16 per square millimeter; fibers nonlibriform..... 21.
20. Vessels 30 to 90 per square millimeter; fibers semilibriform to libriform.
23.

21. Growth rings distinct, delineated by several rows of radially flattened fibers ..... *Dolichandrone spathacea.*
21. Growth rings indistinct ..... 22.
22. Fibers 20 to 28 microns in diameter; rays 10 to 13 per millimeter (*x*), the largest up to 25 cells and 850 microns in height, crystals present in the ray cells ..... *Excoecaria agallocha.*
22. Fibers 30 to 40 microns in diameter; rays 8 or 9 per millimeter (*x*), the largest up to 14 cells and 600 microns in height; crystals not present in the ray cells..... *Cerbera manghas.*
23. Vessels mostly in radially groups of 2 to 7..... 24.
23. Vessels mostly solitary ..... 25.
24. Vessels 30 to 45 per square millimeter, the largest 90 to 100 microns in diameter; parenchyma paratracheal and metatracheal; rays 40 to 60 per square millimeter (*t*)..... *Lumnitzera littorea.*
24. Vessels 60 to 70 per square millimeter, the largest 60 to 70 microns in diameter; parenchyma paratracheal, paratracheal-zonate, and metatracheal; rays 80 to 100 per square millimeter (*t*). *Lumnitzera racemosa.*
25. Rays 25 to 30 per millimeter (*x*); "upright" cells unusually high along the grain (higher than wide), strikingly different in color, owing to infiltration; vessel orifices round; segments occluded with gummy infiltration; fibers septate, 20 to 24 microns in diameter. *Scyphiphora hydrophyllacea.*
25. Rays 15 to 18 per millimeter (*x*); "upright" cells not appreciably elongated vertically (*t*); vessel orifices oval; segments not occluded with gummy infiltration; fibers nonseptate, 8 to 16 microns in diameter ..... *Osbornia octodonta.*

DISCUSSION AND SUMMARY

The anatomical structure of a plant may be considered as resulting from the effects of two factors; namely, "adaptation to environment" and "heredity." It follows that some anatomical features may be interpreted as adaptations to climate and habitat (physiological), while others are to be regarded as inherited (ancestral); the latter often predominate and are, therefore, of greater importance systematically. For instance, among mangrove-forest species, anatomical changes, such as have resulted as a protection against desiccation, are often secondary in importance to inherited characters, at least in so far as classification is concerned. Moreover, as Solereder[29] suggests, different species of plants do not necessarily respond in the same way to the influences of identical stimuli, and in consequence climate and habitat may not impress any one definite type of anatomical structure upon all the species of plants found within a given habitat. This suggestion is more or less sub-

[29] Systematic Anatomy of Dicotyledons 1:9.

stantiated by the anatomy of mangrove-forest woods, since an extremely specialized site has failed to produce identical structural changes in different species.

In the study of mangrove-forest plants, the attention of investigators has been focused chiefly on the alterations that have resulted in the external organs, and to a lesser extent in the roots. It should be interesting, therefore, to see in what way, if any, a highly saline and hence a physiologically dry habitat has affected the structure of the woods of those trees which have been able to adapt themselves to such extremely xerophytic conditions. With this idea in mind the anatomical data obtained from a detailed study of the woods of the littoral Philippine species were examined critically in order to determine what anatomical changes could be interpreted as adaptations to habitat.

The woods of all species were found to be typical diffuse porous (growth rings either wanting or poorly outlined), very fine textured, and in most cases in addition possessed fairly numerous or extremely numerous vessels (30 to over 200 plus per square millimeter in *Aegiceras*). Those in which the vessels are not numerous (less than 15 to the square millimeter) are characterized by thin-walled fibers with wide lumina. The diameters of the vessels were found to be small or very small, with a maximum diameter rarely exceeding 150 microns (usually less than 100 microns). The last values are considerably below the average for a similar number of species growing under normal (upland) conditions. On the other hand, the length of the vessel segments, which ranges from 150 to 1,200 microns, proved not to be conspicuously different from that of closely allied species of different habitat. All the species of the subfamily Rhizophoræ are littoral and possess scalariform perforations, as contrasted with the Legnotidæ—the inland Rhizophoraceæ of mesophytic habitat—which have either scalariform or simple perforations (mostly simple). This perhaps may be taken as an indication of a retarding influence of a xerophytic habitat on the evolutionary changes in the structure of the wood elements. Even in this case, however, this influence is apparent only in closely allied species since the wood of all other "littorals" (other than the Rhizophoraceæ) covered in this paper have simple perforations; the lone exception is that of *Dolichandrone*, which possesses a rare type of reticulate perforation in addition to the simple type. The fibers are usually

thick walled and often septate, with simple or bordered pits, and with a high infiltration content. Wood parenchyma is fairly abundant (absent in *Sonneratia*), and generally reaches its best development around the vessels. Exceptions appear in *Camptostemon, Cerbera, Scyphiphora, Dolichandrone, Excoecaria,* and *Heritiera* where paratracheal-zonate parenchyma predominates. The rays range from uniseriate to multiseriate; those of the latter type are from 2- to 10-seriate, and attain a considerable height (5 millimeters to 1 centimeter) in *Rhizophora* and *Bruguiera.*

Anomalous structures of various types are frequent in the woods of the mangrove forest, among which the concentric bands of outer xylary phloëm in *Avicennia,* the scattered bundles of phloëm near the pith in *Lumnitzera* and *Sonneratia,* the gum cysts in the rays of *Aegiceras,* and the peculiar reticulate perforations of *Dolichandrone* are worthy of special note.

The results of this brief anatomical survey of the woods of the Philippine mangrove forests are in agreement with Solereder's hypothesis; namely, that habitat does not impress any definite type of anatomical structure upon different species. This is shown by the fact that no matter what structural changes have taken place in the wood of the mangroves, these changes are not identical in different species. Naturally, more-extensive research is necessary before any definite conclusions can be drawn, and future investigators would do well to conduct their researches along three lines; namely, an examination and a comparative study of the woods of littoral species from different localities; a comparative study of their anatomy, with that of closely allied species, growing under different conditions; and the evolutionary significance of such changes as appear to have resulted from the influence of a specialized environment.

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ILLUSTRATIONS

[The wood of one species is figured in cross section on each plate. The upper figure is magnified × 15; the lower, × 110.]

PLATE 1. *Cerbera manghas* Linn.
2. *Xylocarpus granatum* Koen.
3. *Xylocarpus moluccensis* (Lam.) M. Roem.
4. *Excoecaria agallocha* Linn.
5. *Camptostemon philippinense* (Vid.) Becc.
6. *Heritiera littoralis* Dryand.
7. *Sonneratia caseolaris* (Linn.) Engl.
8. *Sonneratia acida* Linn. f.
9. *Bruguiera conjugata* (Linn.) Merr.
10. *Bruguiera cylindrica* (Linn.) Blume.
11. *Bruguiera sexangula* (Lour.) Poir.
12. *Bruguiera parviflora* (Roxb.) W. and A.
13. *Ceriops roxburghiana* Arn.
14. *Ceriops tagal* (Perr.) C. B. Rob.
15. *Rhizophora mucronata* Lam.
16. *Rhizophora apiculata* Blume.
17. *Osbornia octodonta* F. Muell.
18. *Lumnitzera littorea* (Jack) Voigt.
19. *Lumnitzera racemosa* Willd.
20. *Aegiceras corniculatum* (Linn.) Blanco.
21. *Aegiceras floridum* R. and S.
22. *Avicennia marina* (Forsk.) Vierh.
23. *Dolichandrone spathacea* (Linn. f.) K. Schum.
24. *Scyphiphora hydrophyllacea* Gaertn. f.

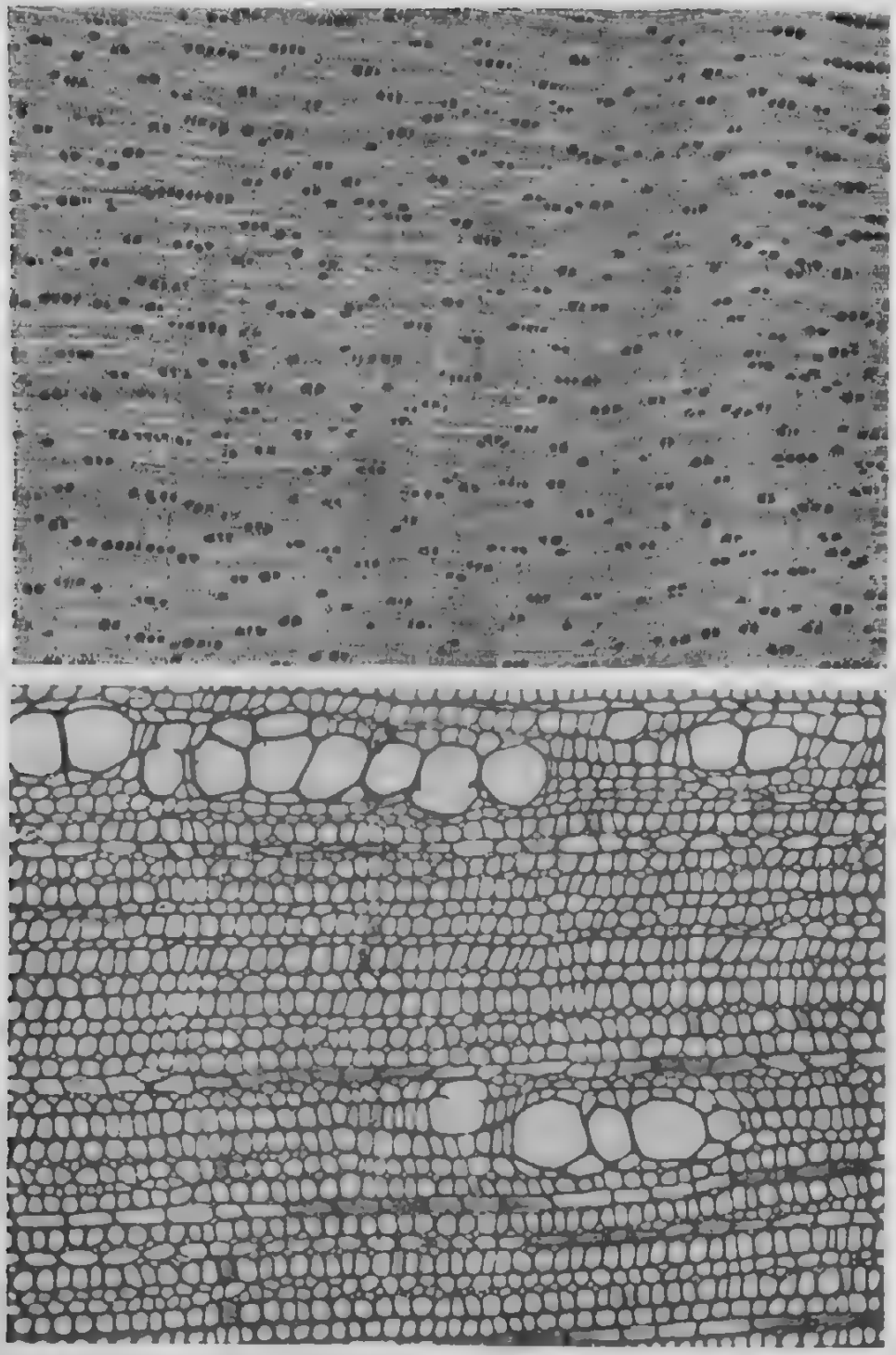

PLATE 1. CERBERA MANGHAS LINN.

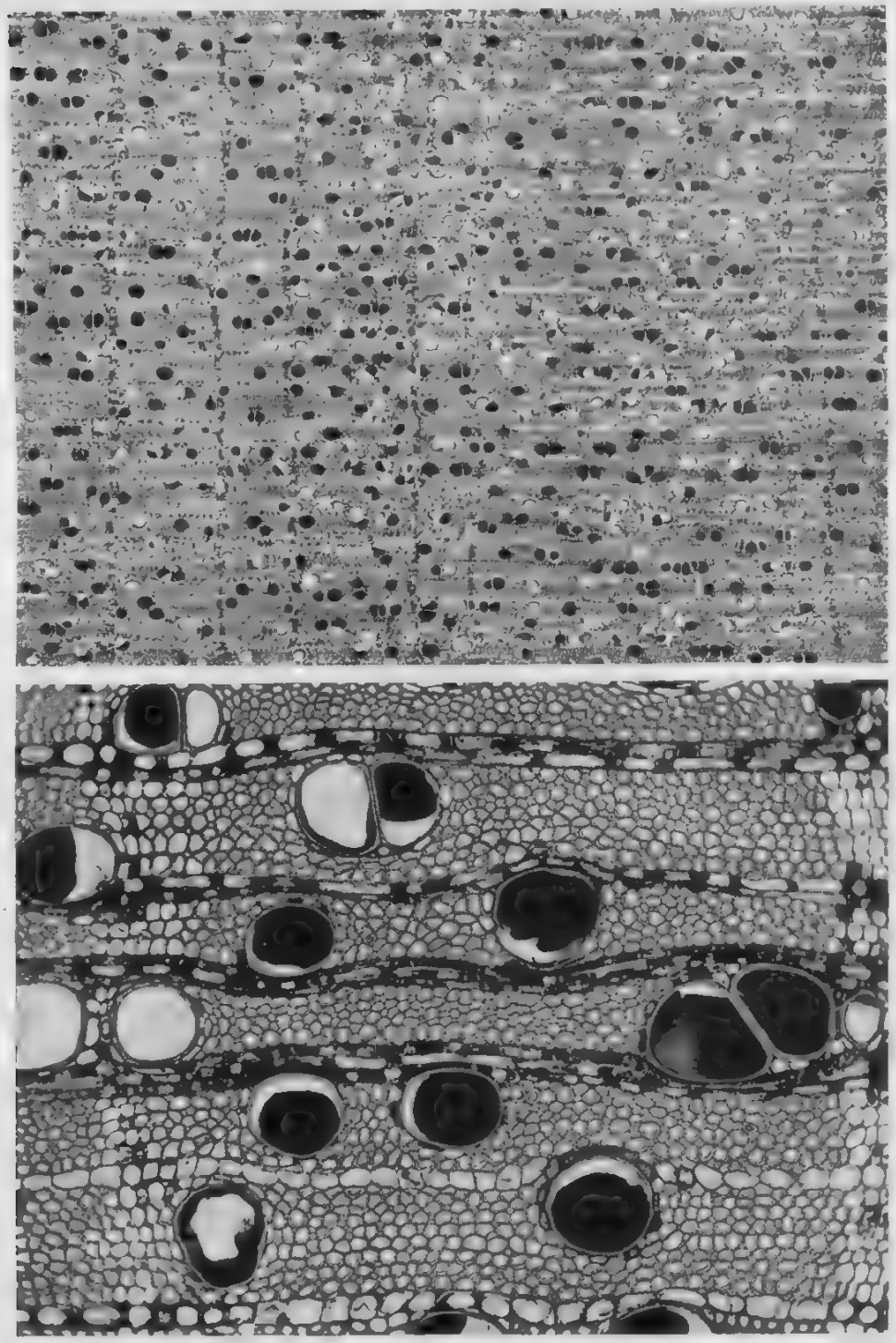

PLATE 2. XYLOCARPUS GRANATUM KOEN.

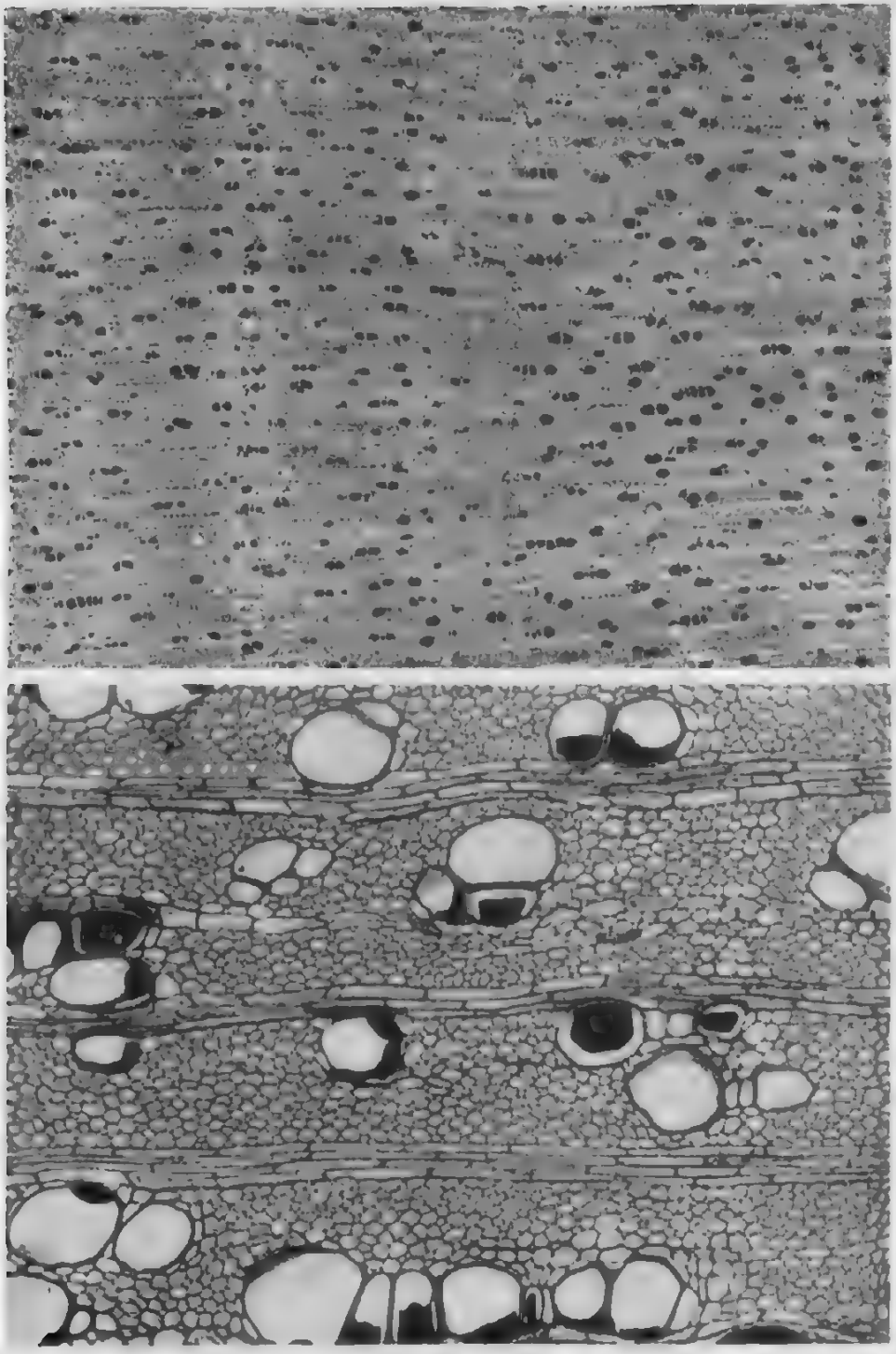

PLATE 3. XYLOCARPUS MOLUCCENSIS (LAM.) M. ROEM.

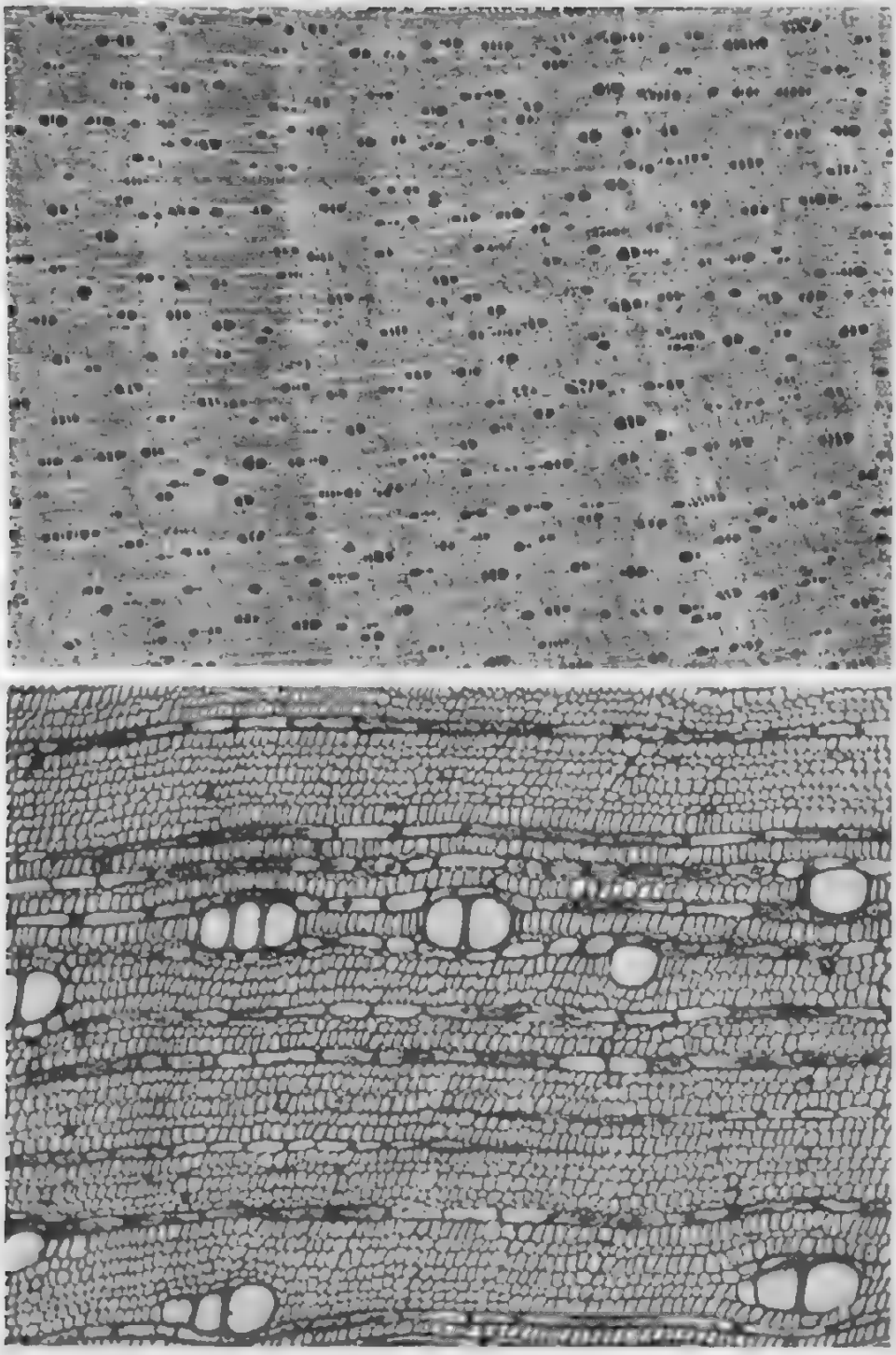

PLATE 4. EXCOECARIA AGALLOCHA LINN.

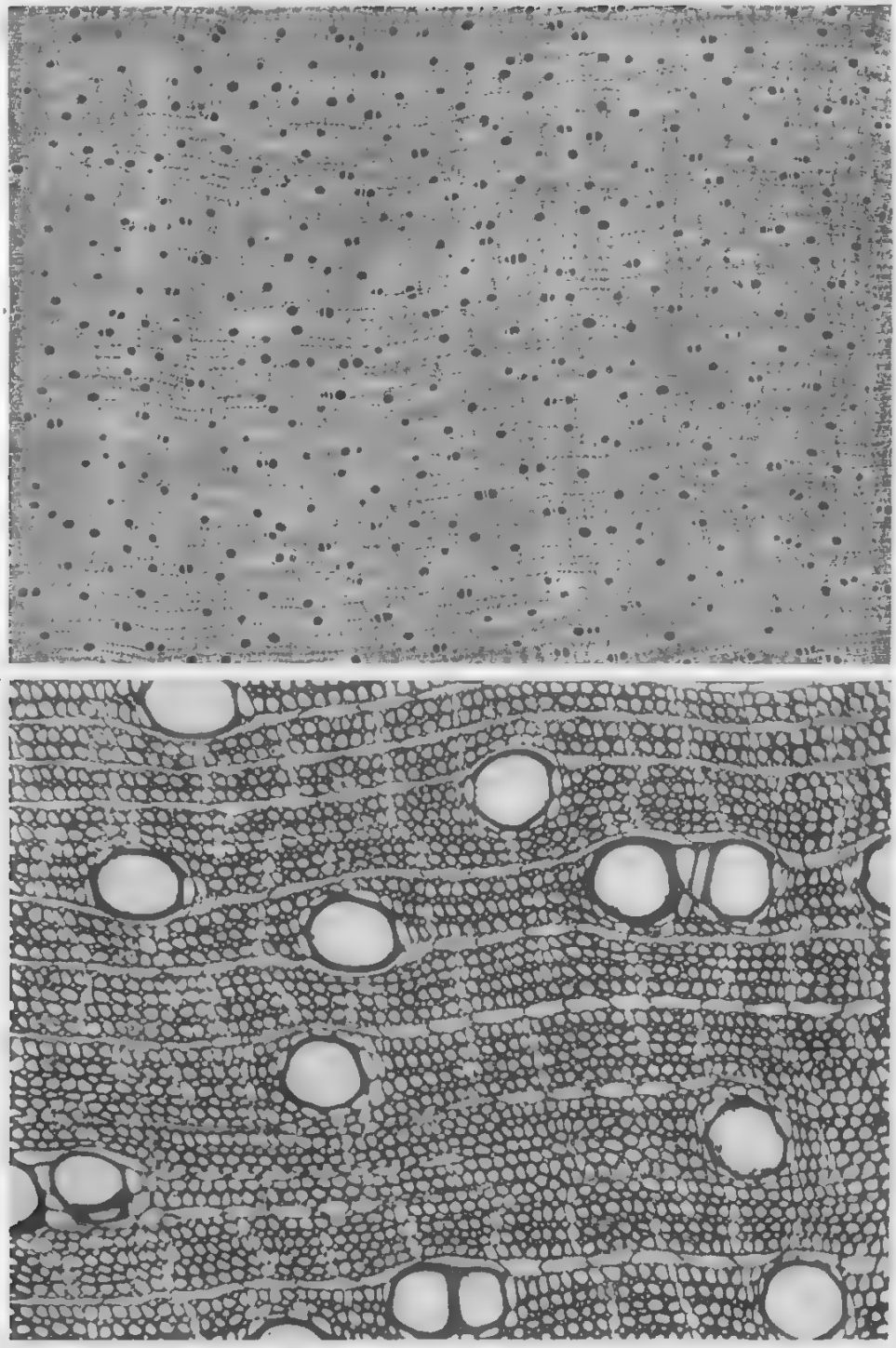

PLATE 5. CAMPTOSTEMON PHILIPPINENSE (VID.) BECC.

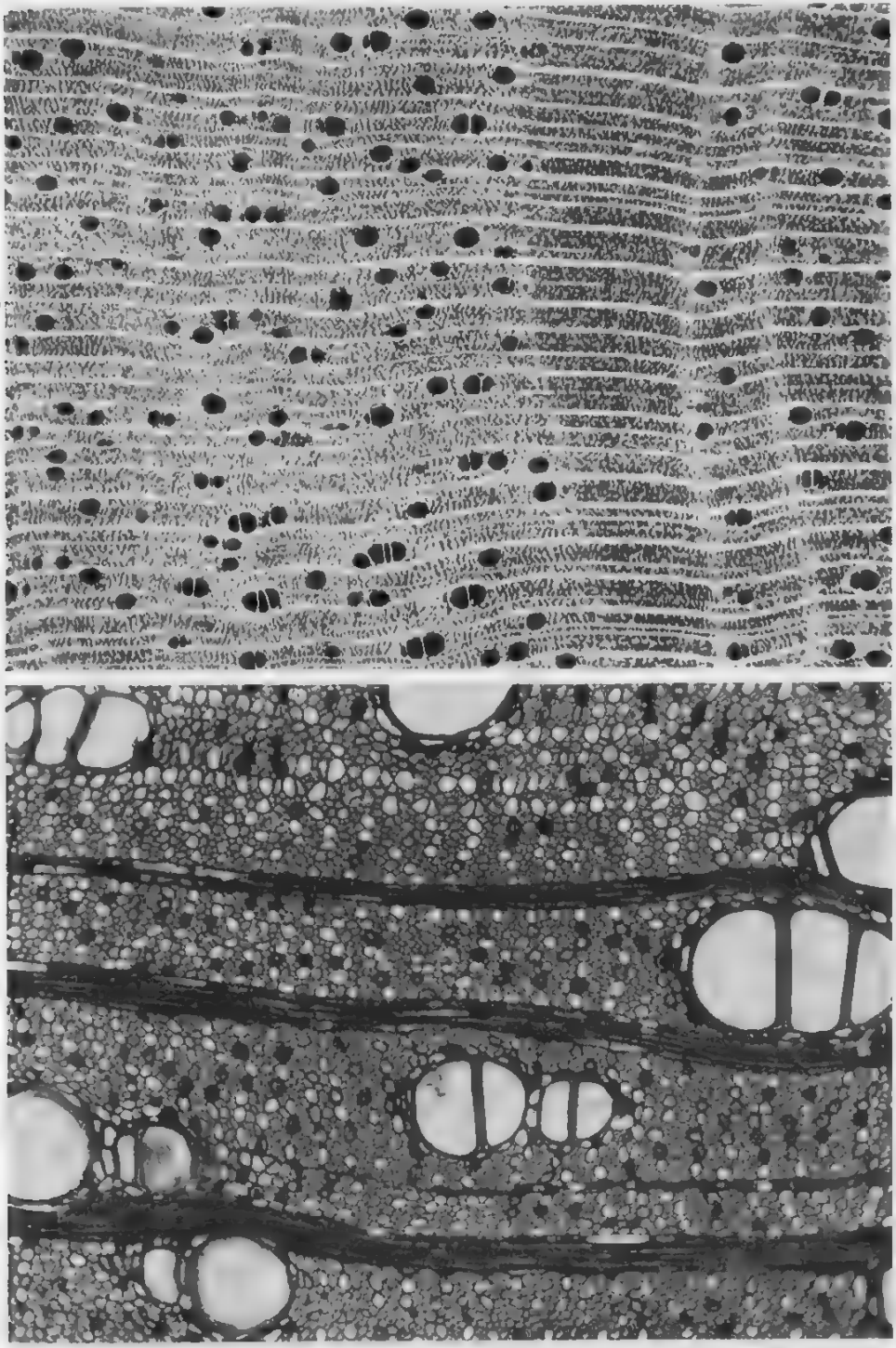

PLATE 6. HERITIERA LITTORALIS DRYAND.

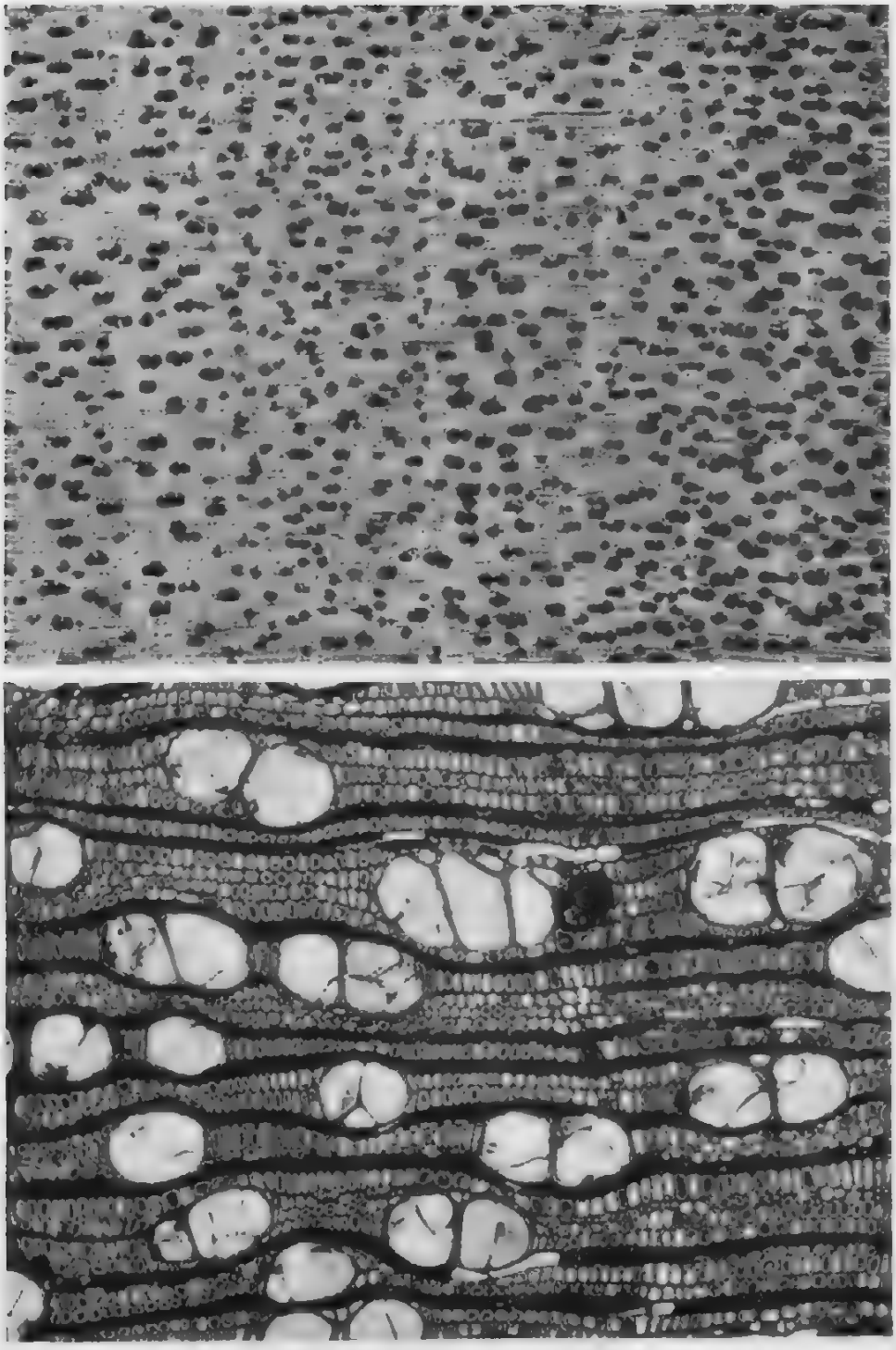

PLATE 7. SONNERATIA CASEOLARIS (LINN.) ENGL.

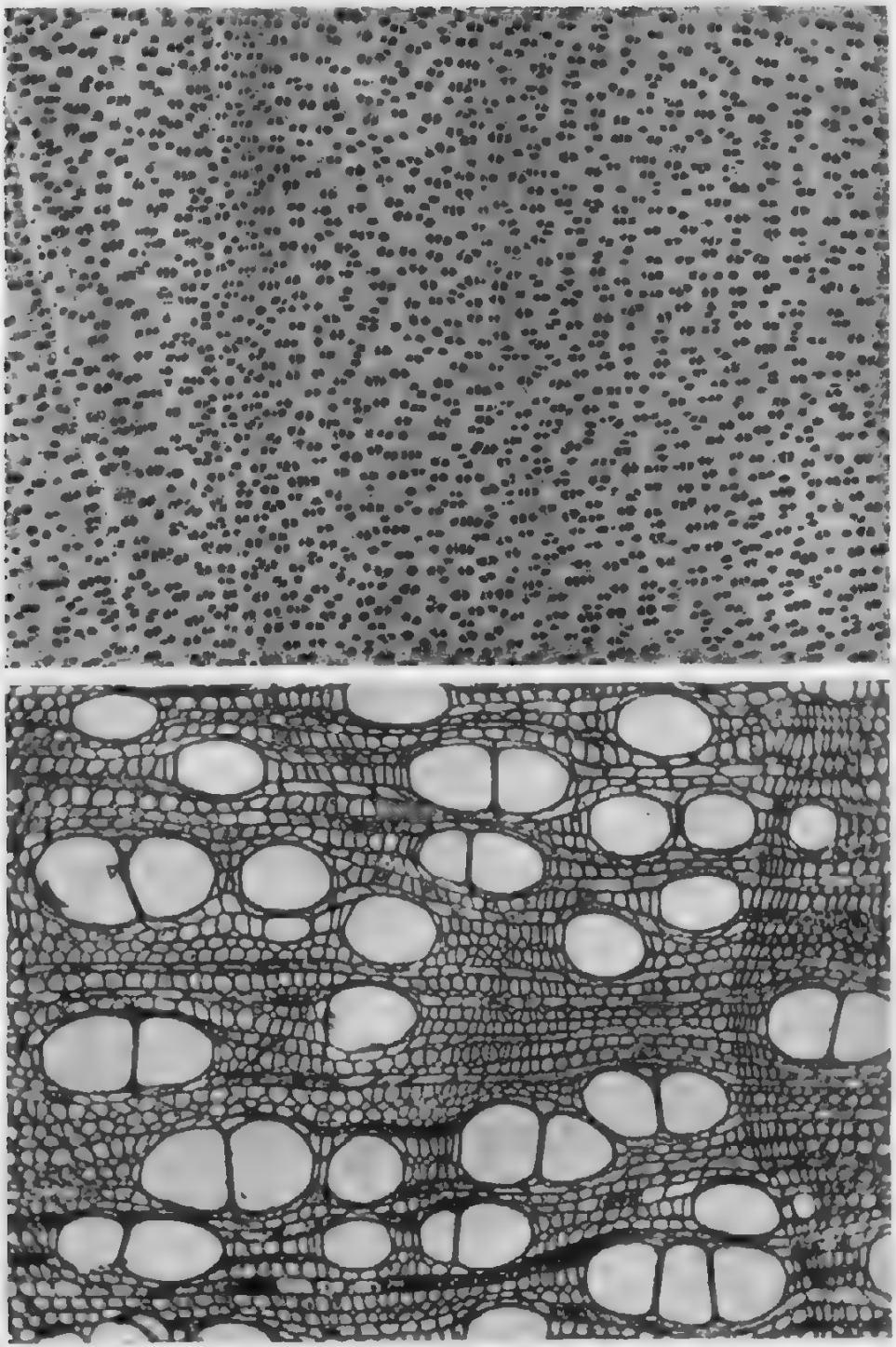

PLATE 2. SONNERATIA ACIDA LINN. F.

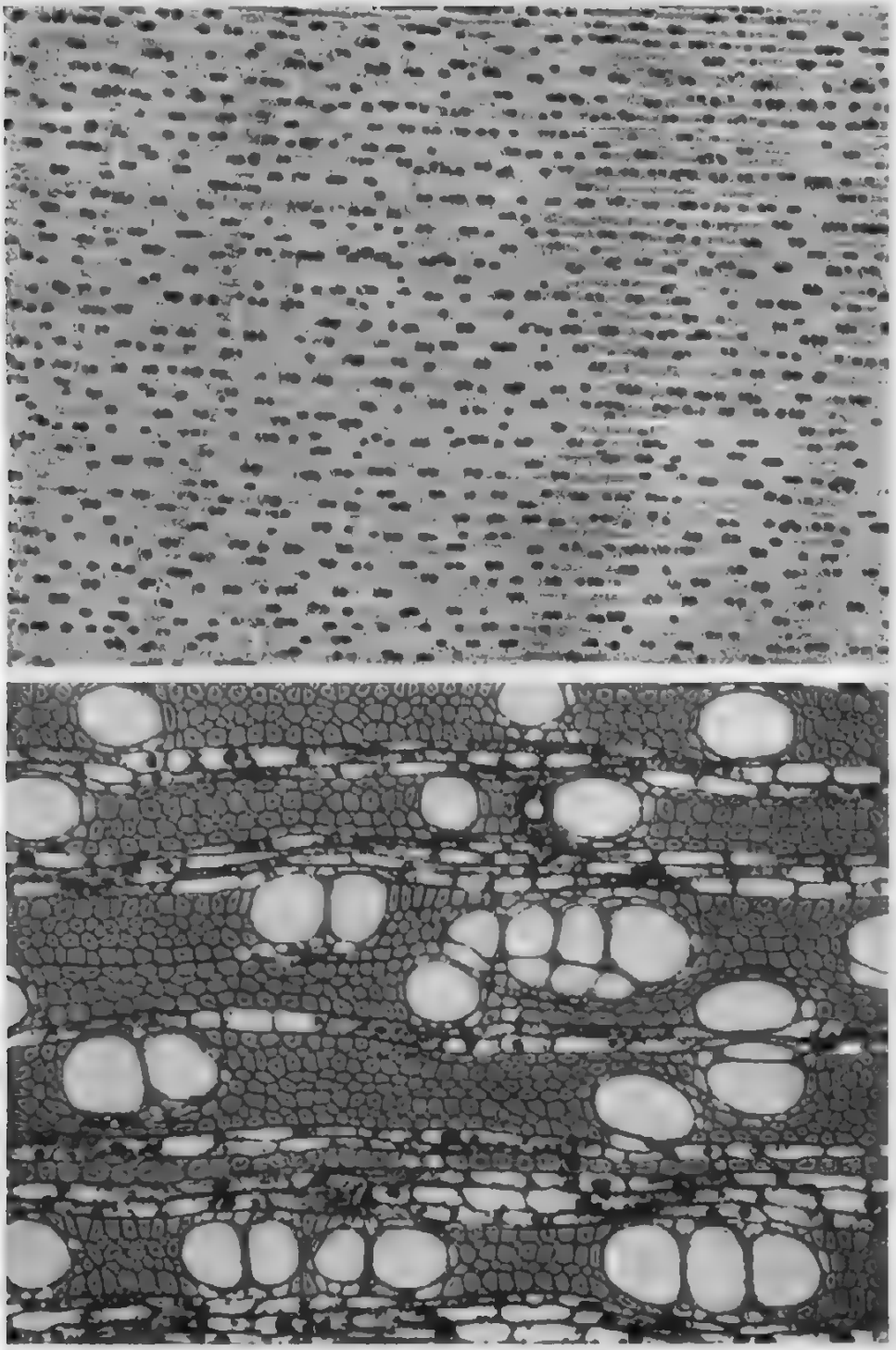

PLATE 9. BRUGUIERA CONJUGATA (LINN.) MERR.

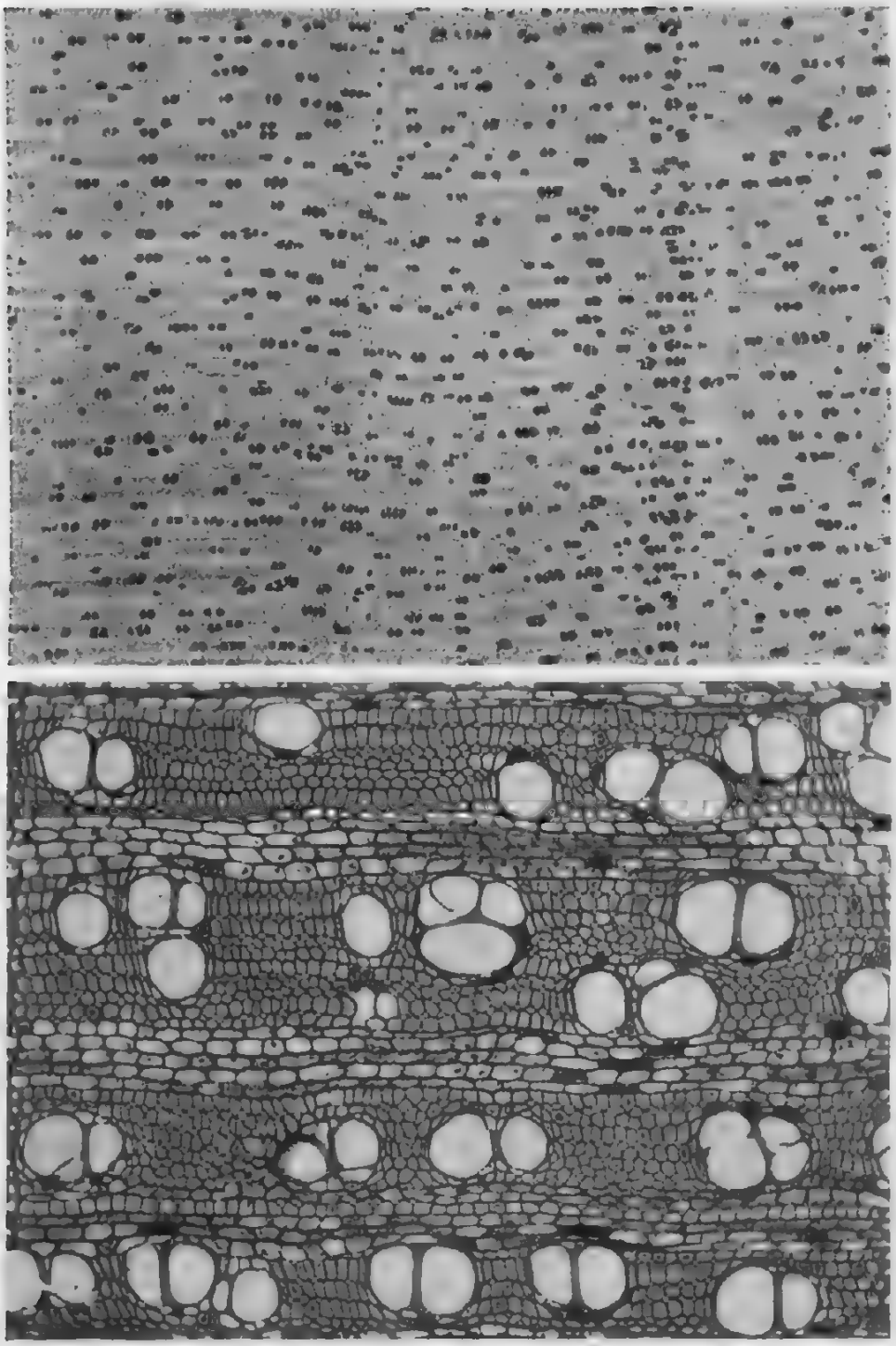

PLATE 10. BRUGUIERA CYLINDRICA (LINN.) BLUME.

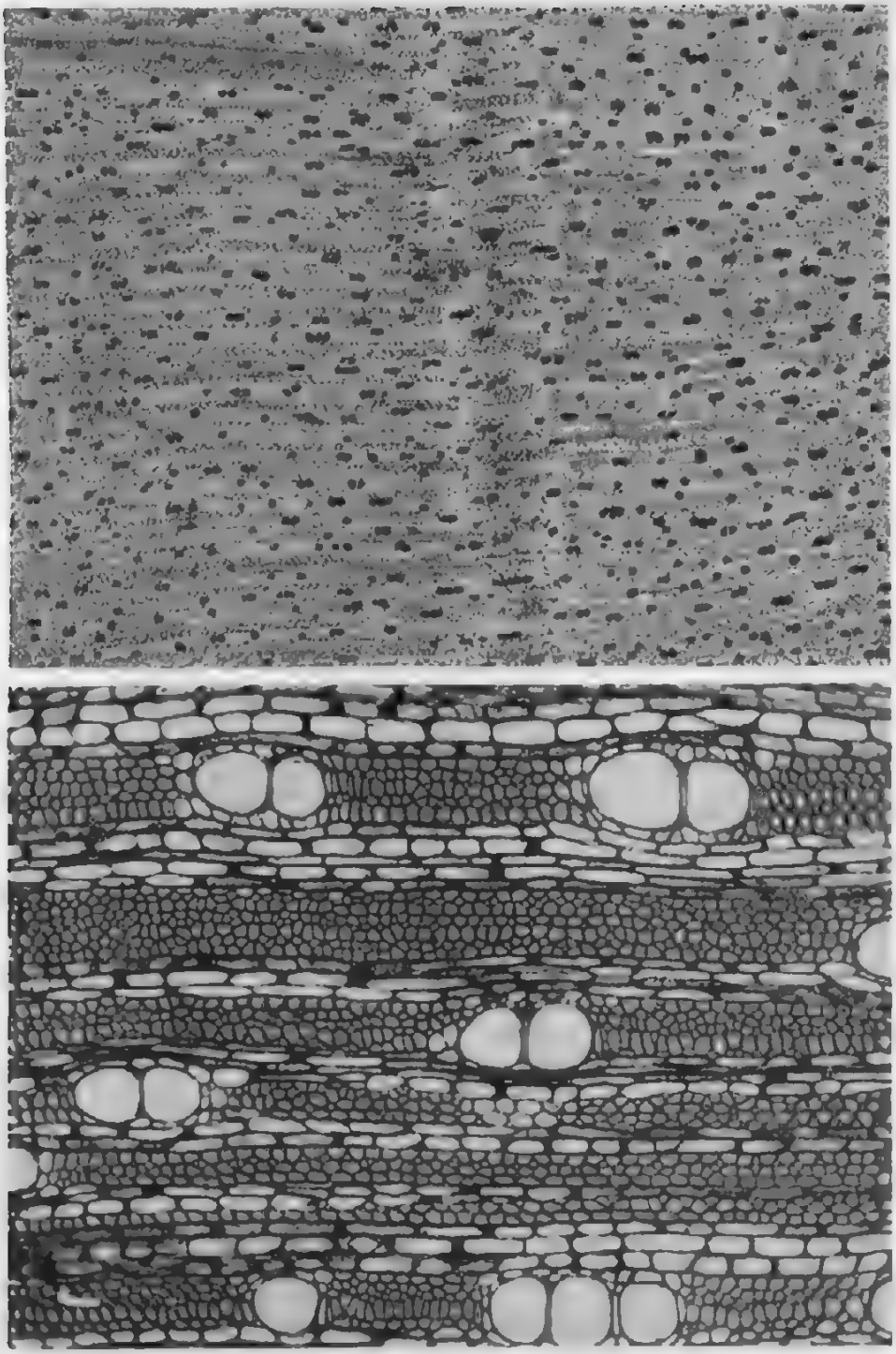

PLATE 11. BRUGUIERA SEXANGULA (LOUR.) POIR.

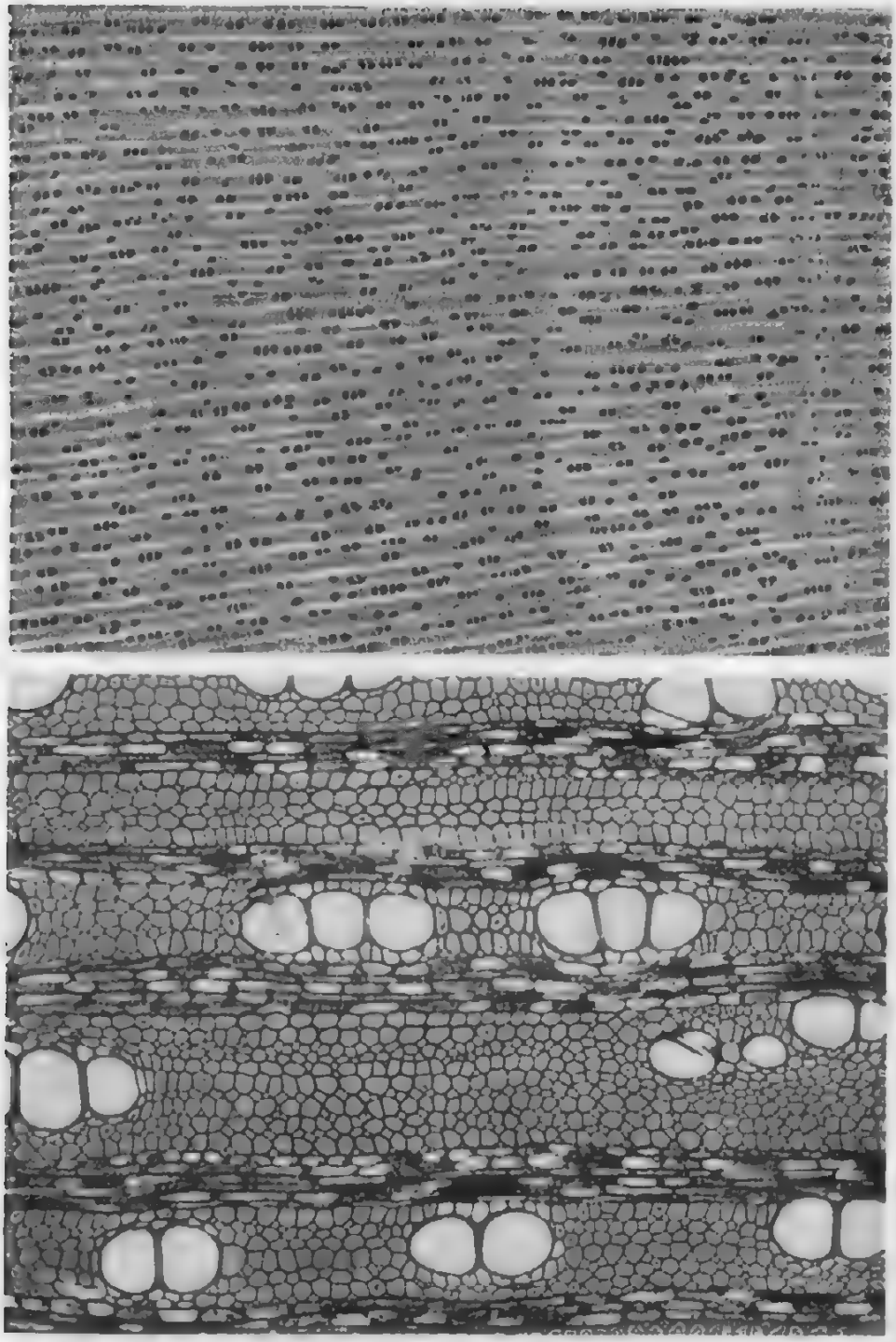

PLATE 12. BRUGUIERA PARVIFLORA (ROXB.) W. AND A.

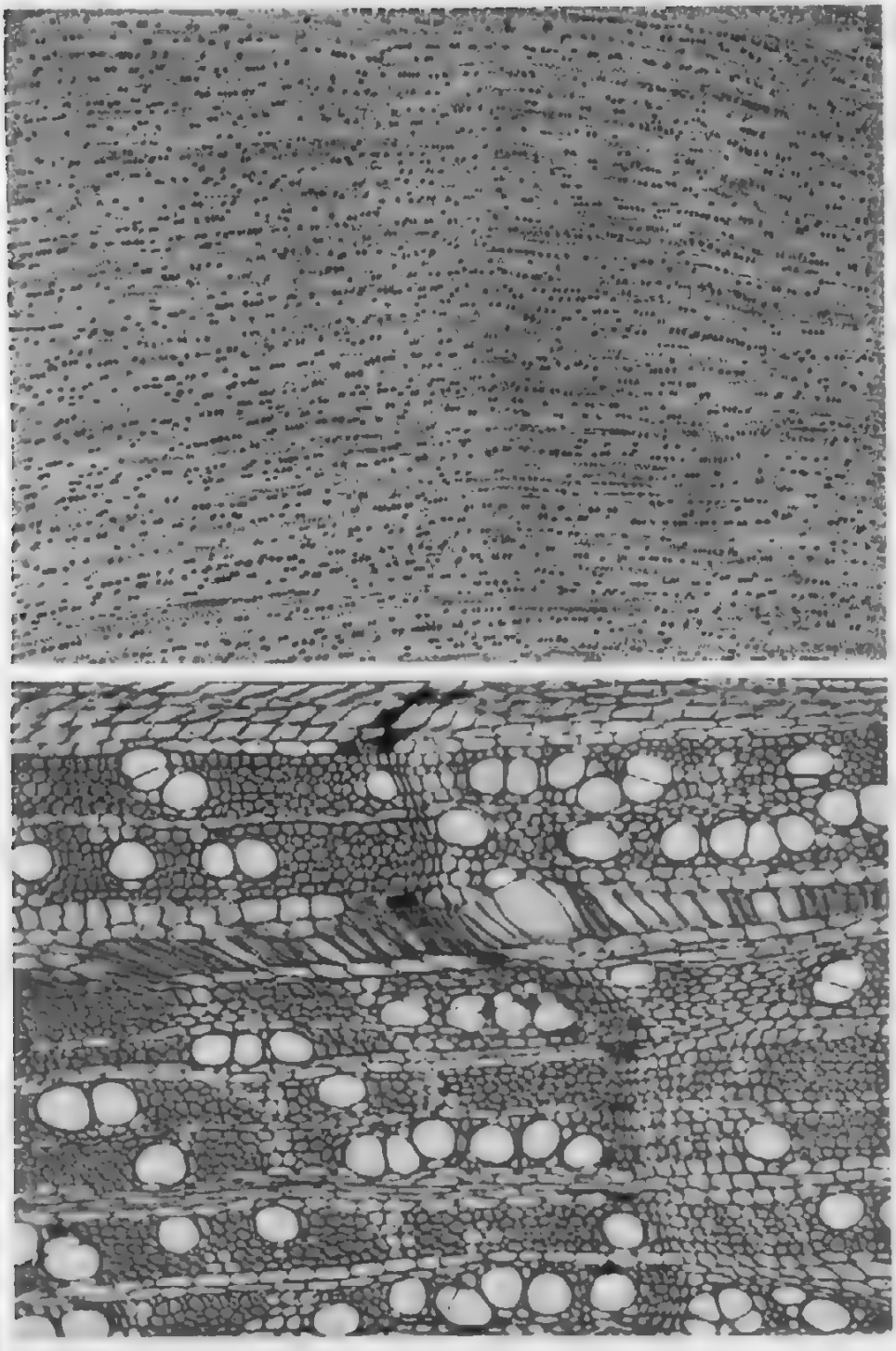

PLATE 13. CERIOPS ROXBURGHIANA ARN.

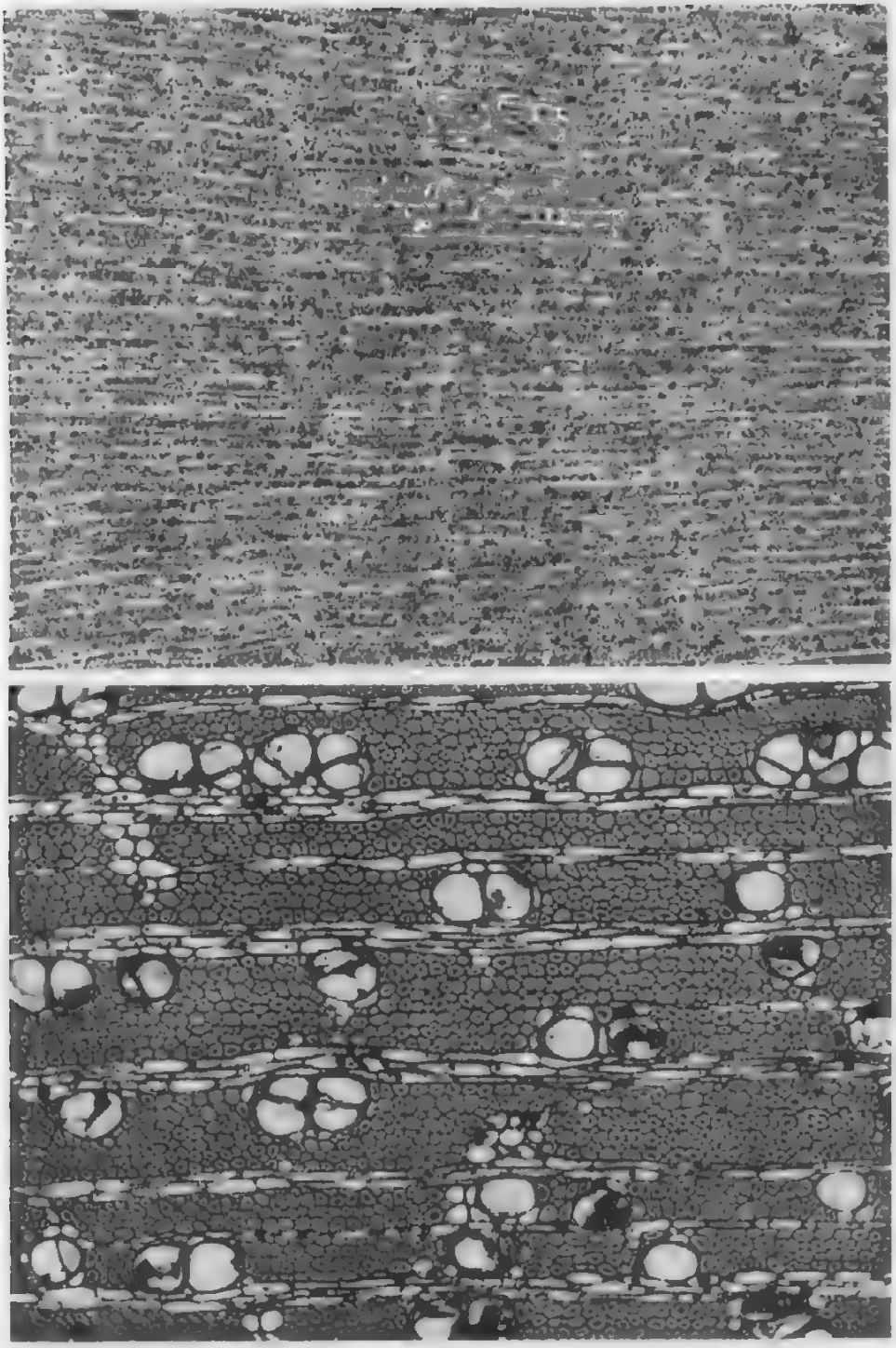

PLATE 14. CERIOPS TAGAL (PERR.) C. B. ROB

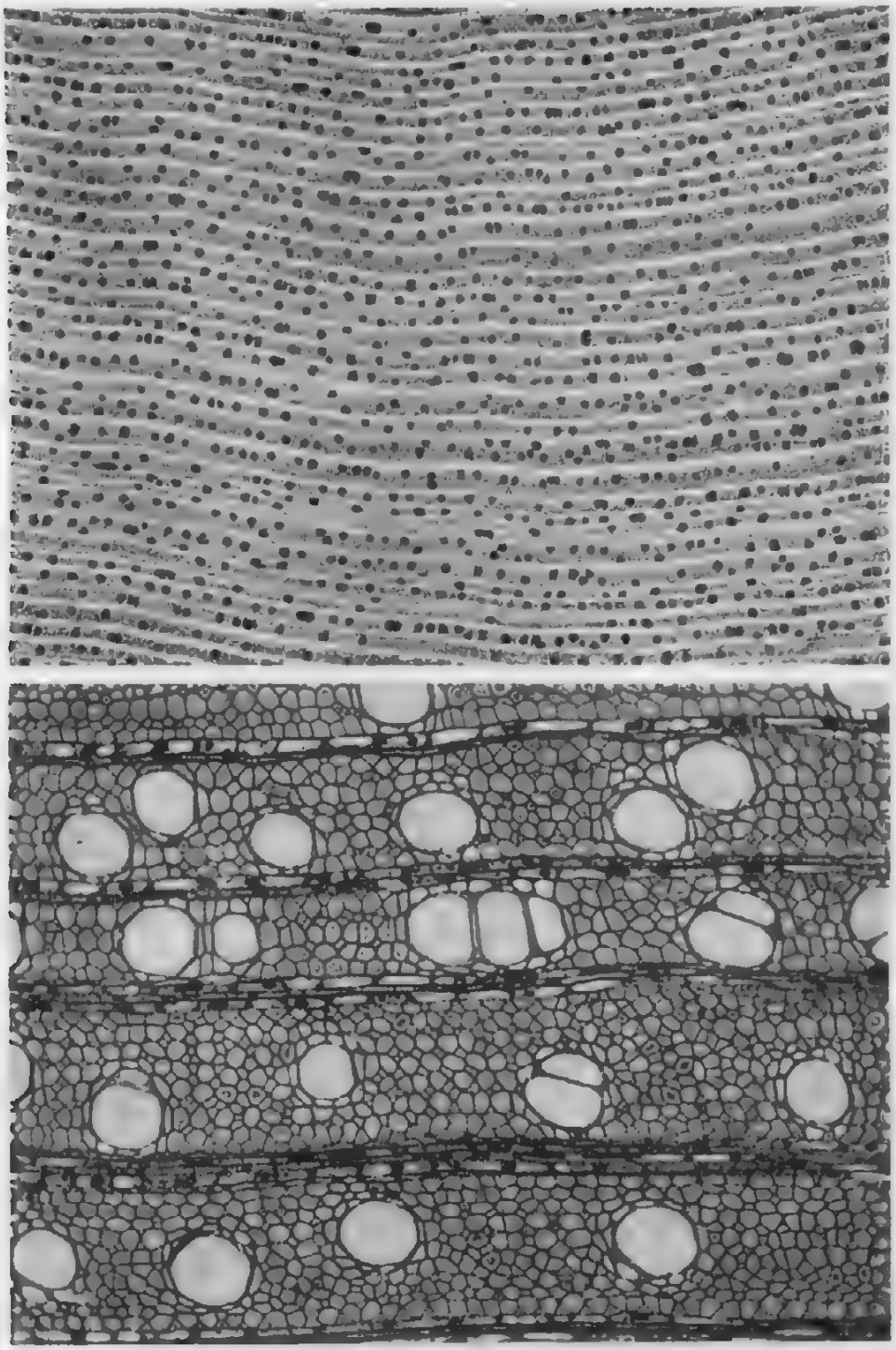

PLATE 15. RHIZOPHORA MUCRONATA LAM.

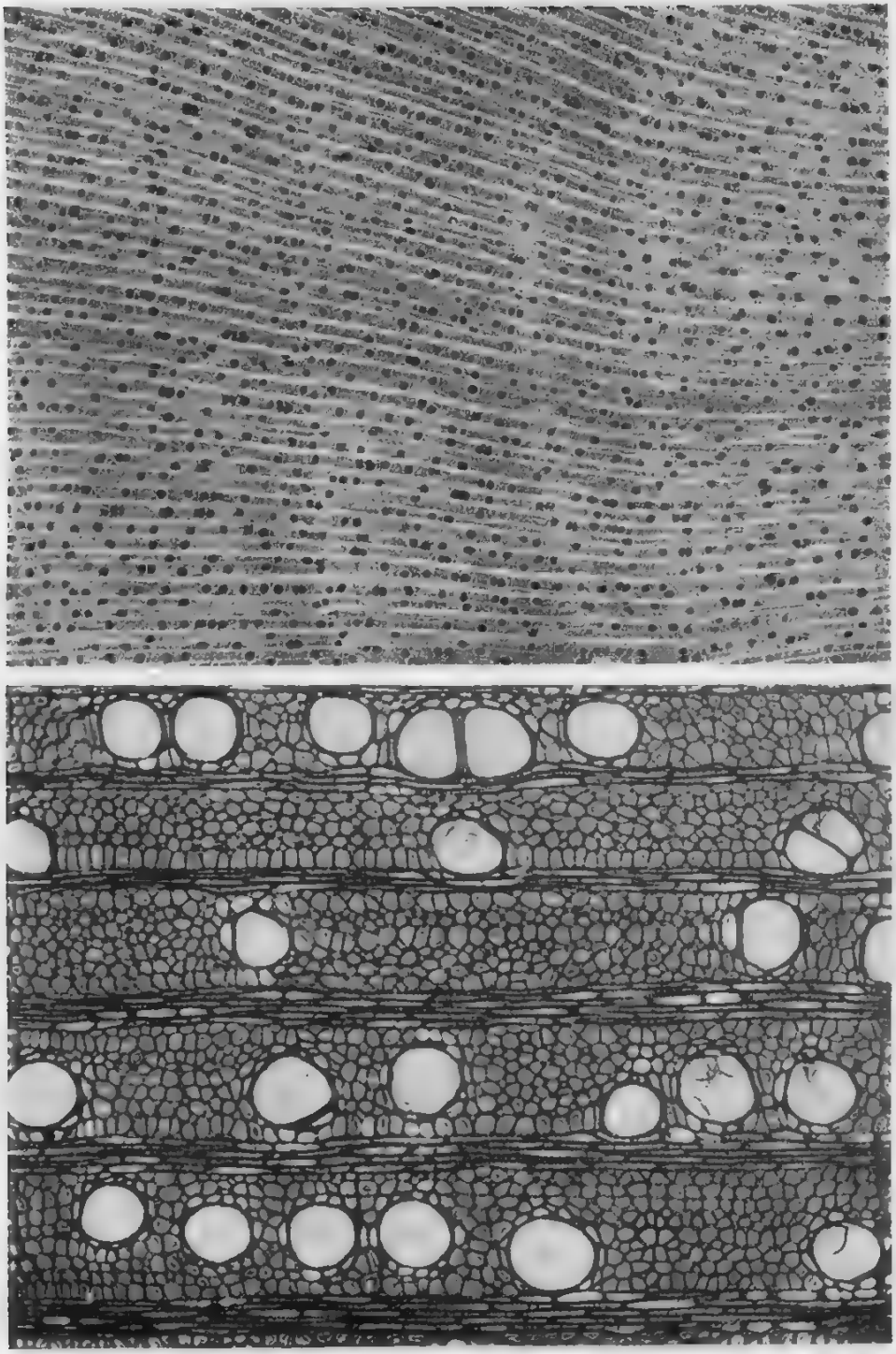

PLATE 16. RHIZOPHORA APICULATA BLUME.

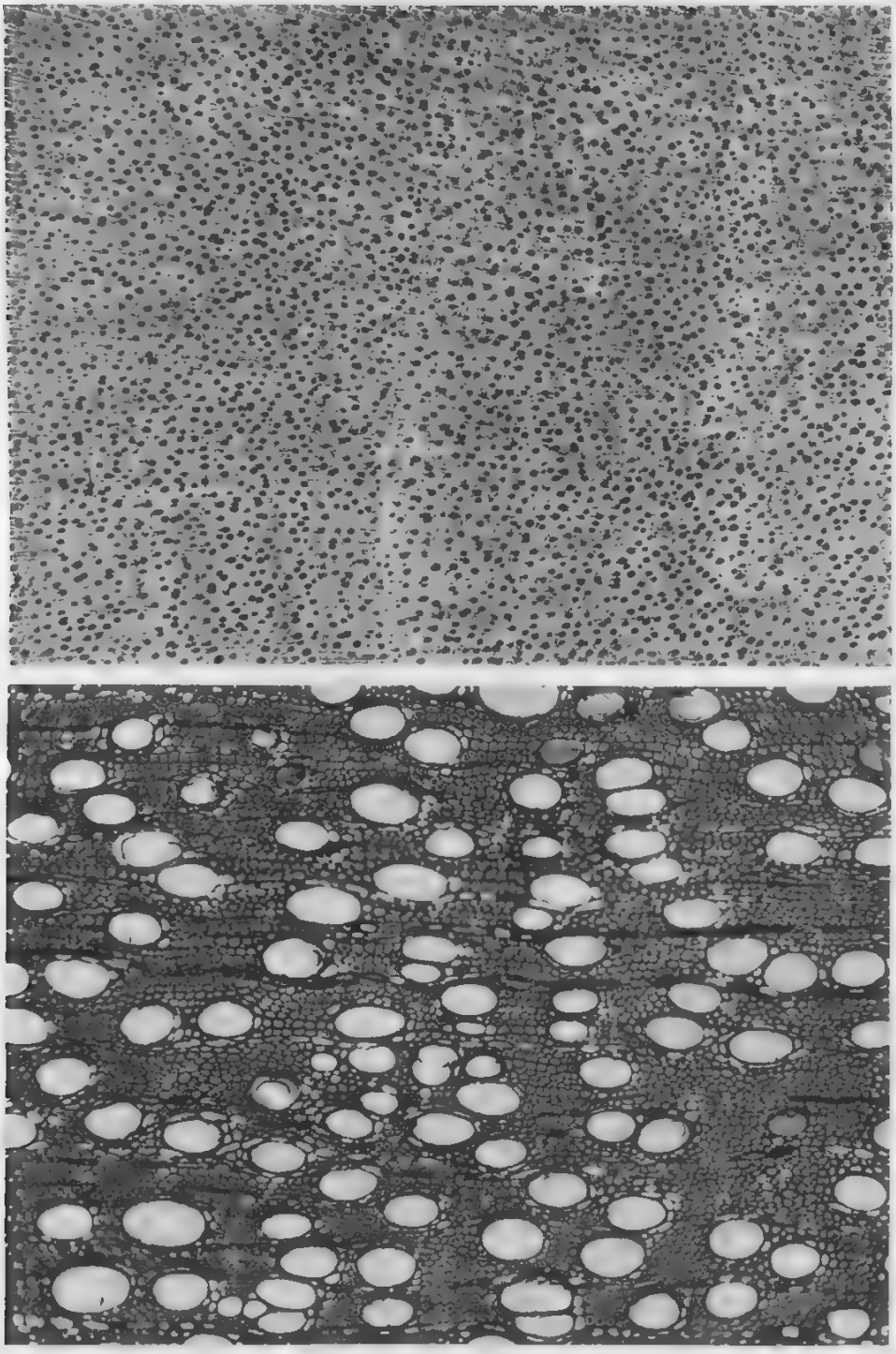

PLATE 17. OSBORNIA OCTODONTA F. MUELL.

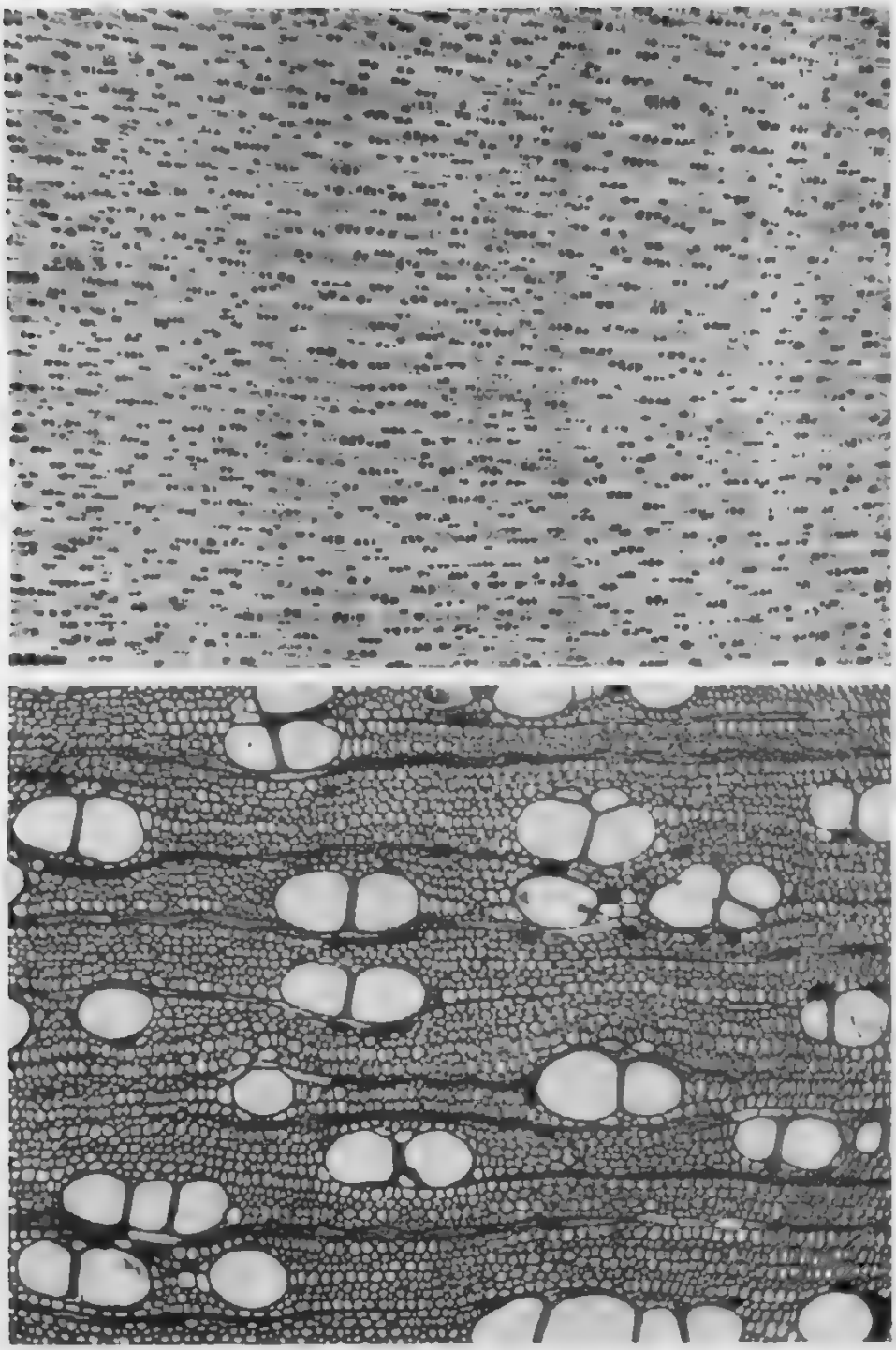

PLATE 18. LUMNITZERA LITTOREA (JACK) VOIGT.

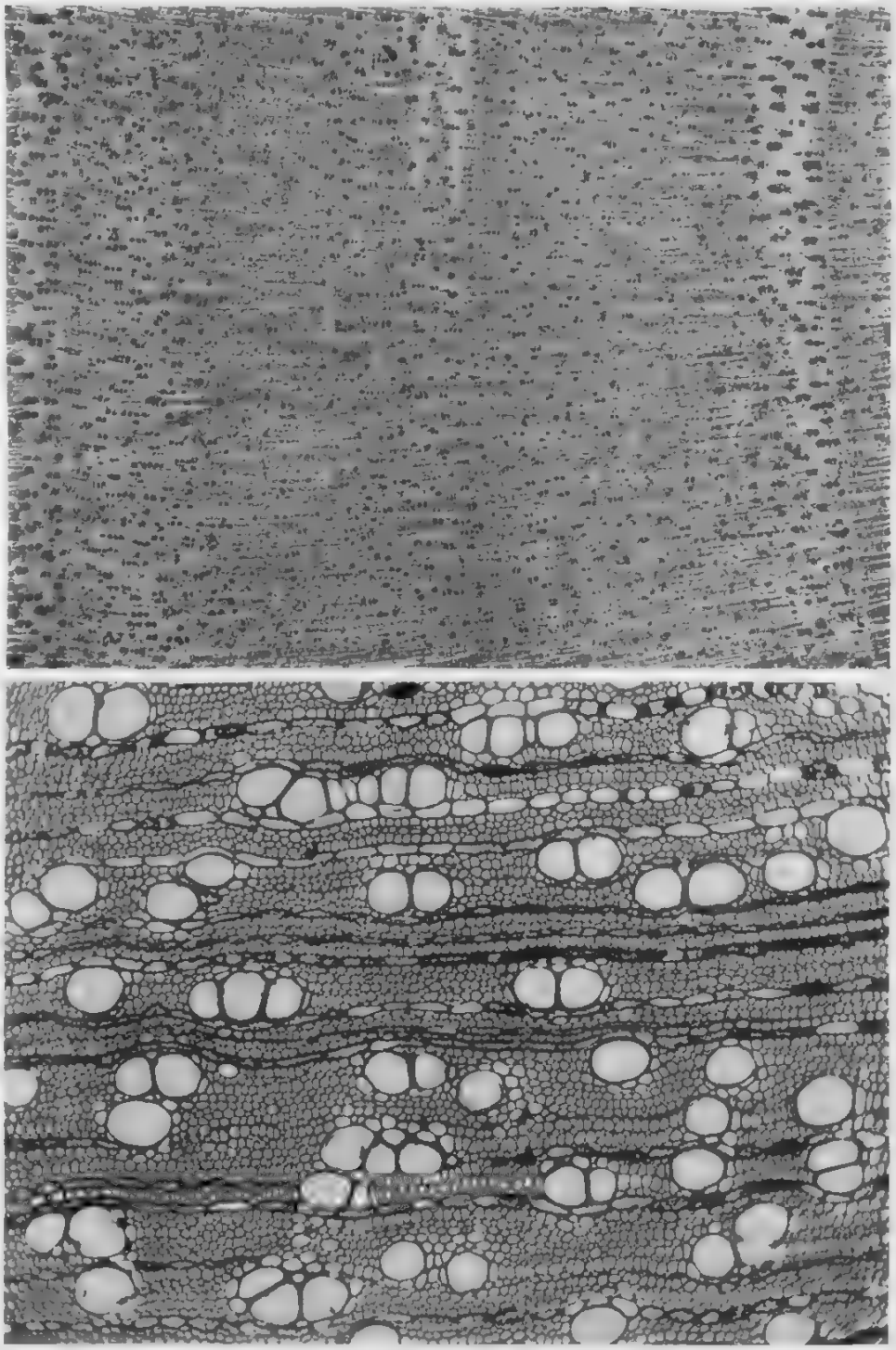

PLATE 19. LUMNITZERA RACEMOSA WILLD.

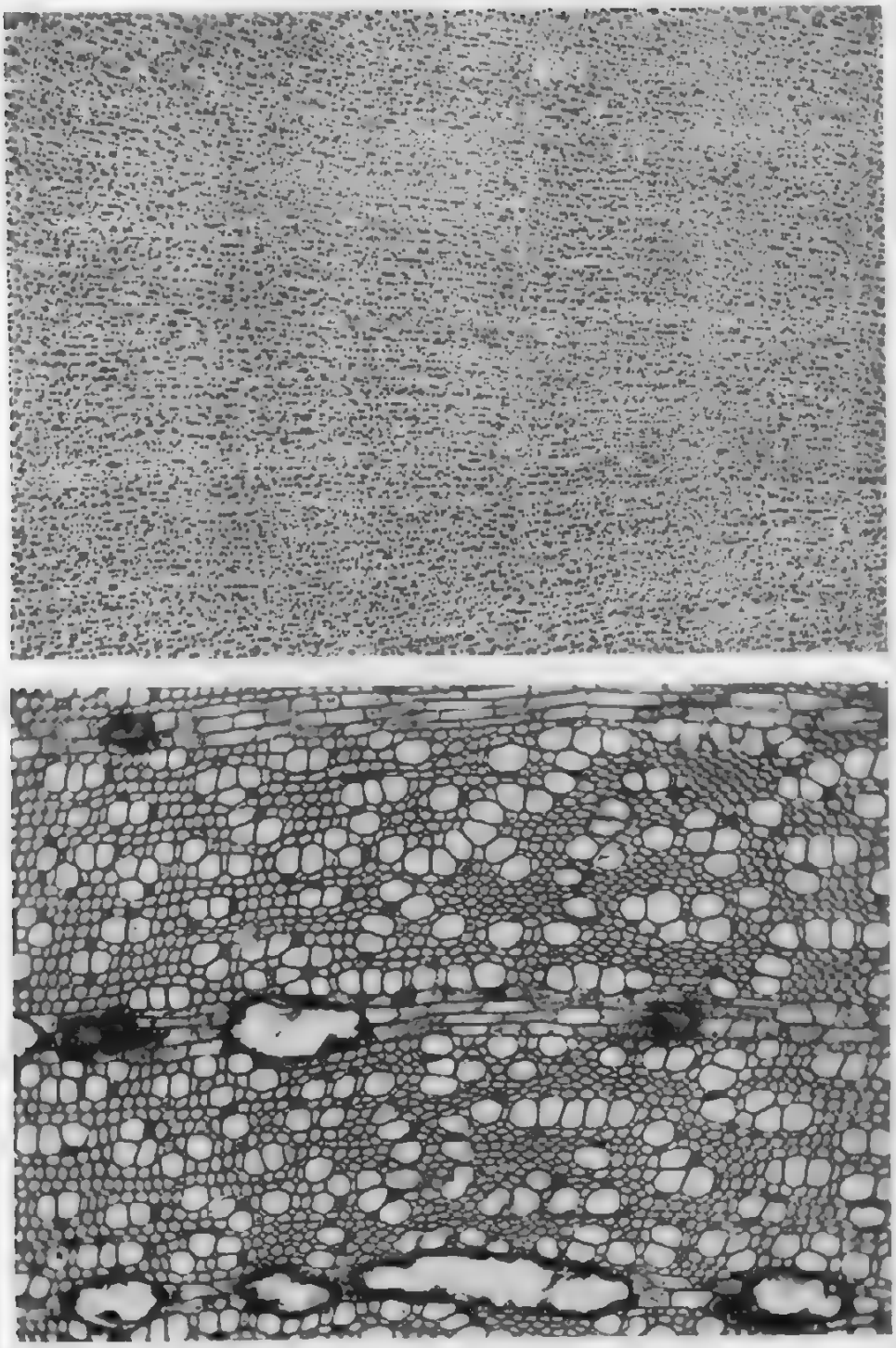

PLATE 20. AEGICERAS CORNICULATUM (LINN.) BLANCO.

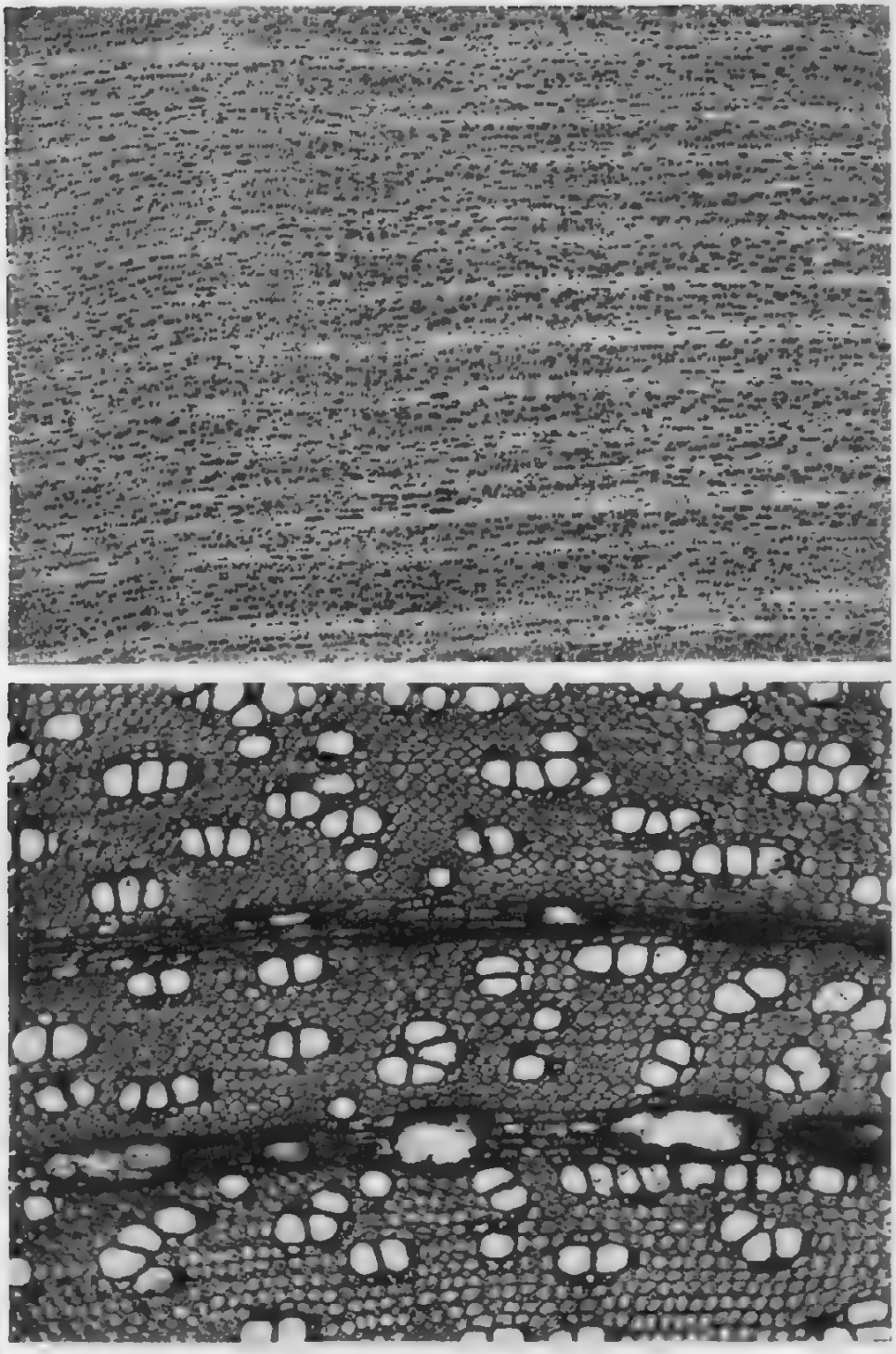

PLATE 21. AEGICERAS FLORIDUM R. AND S.

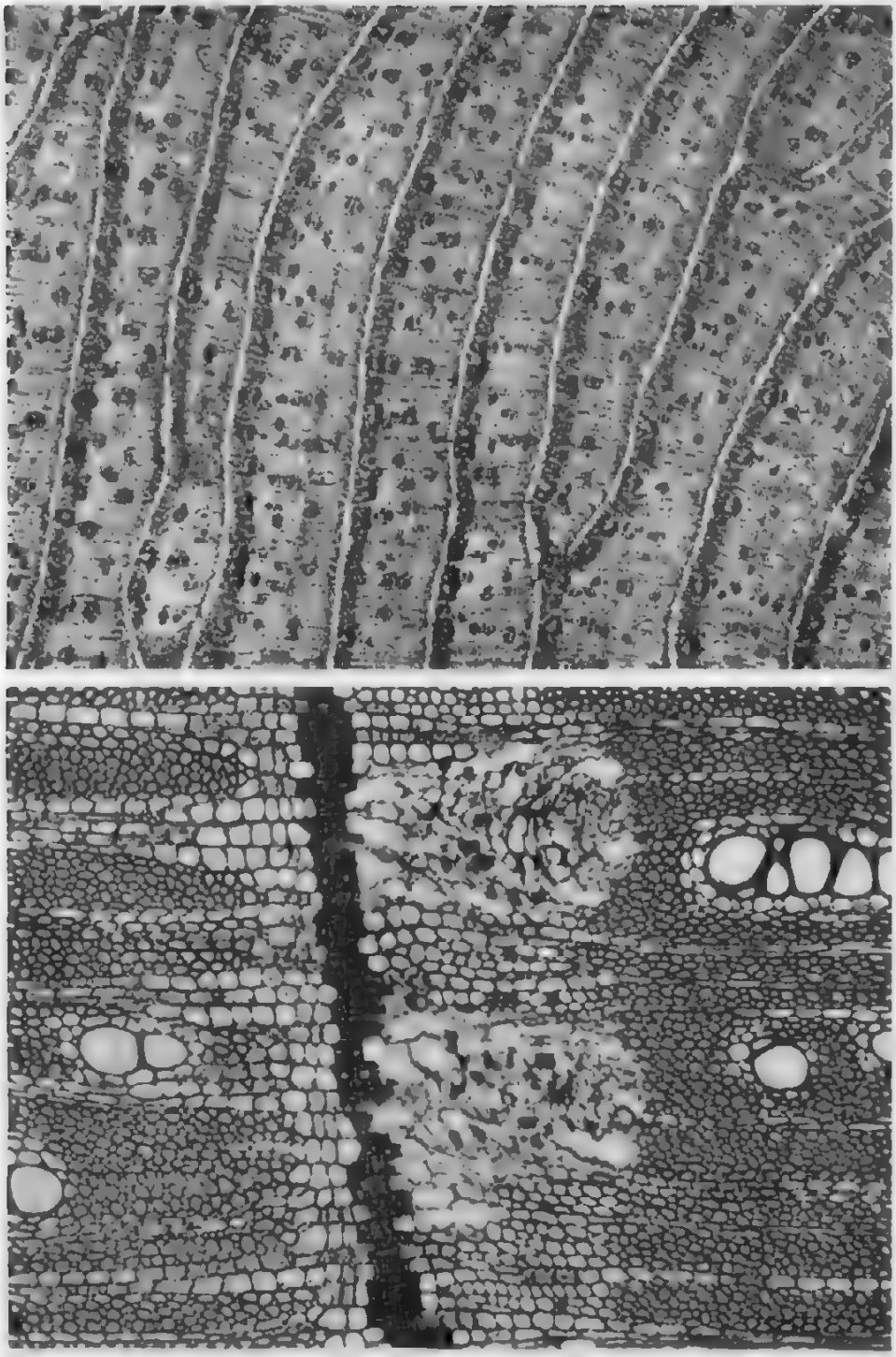

PLATE 22. AVICENNIA MARINA (FORSK.) VIERH.

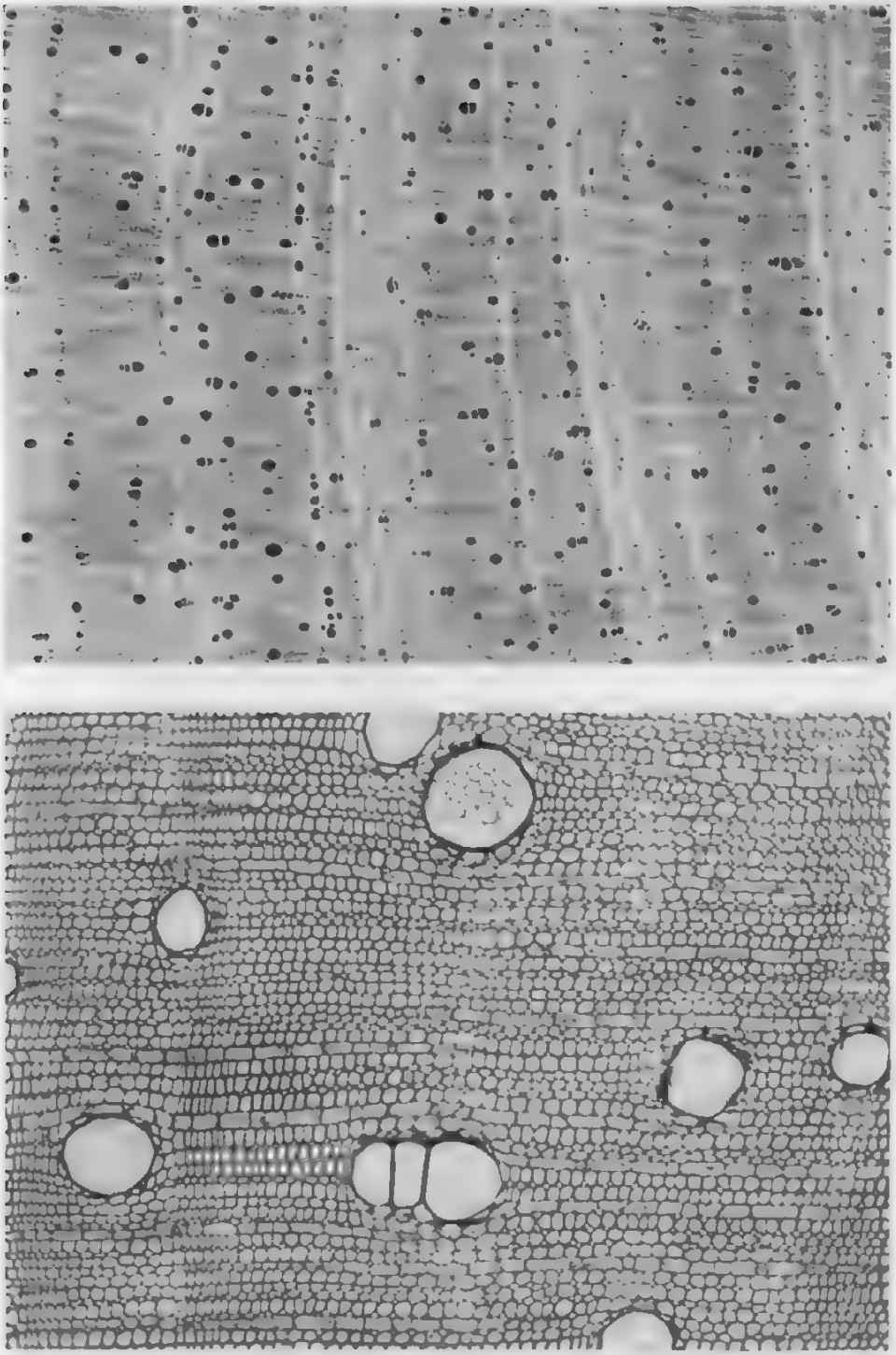

PLATE 23. DOLICHANDRONE SPATHACEA (LINN. F.) K. SCHUM.

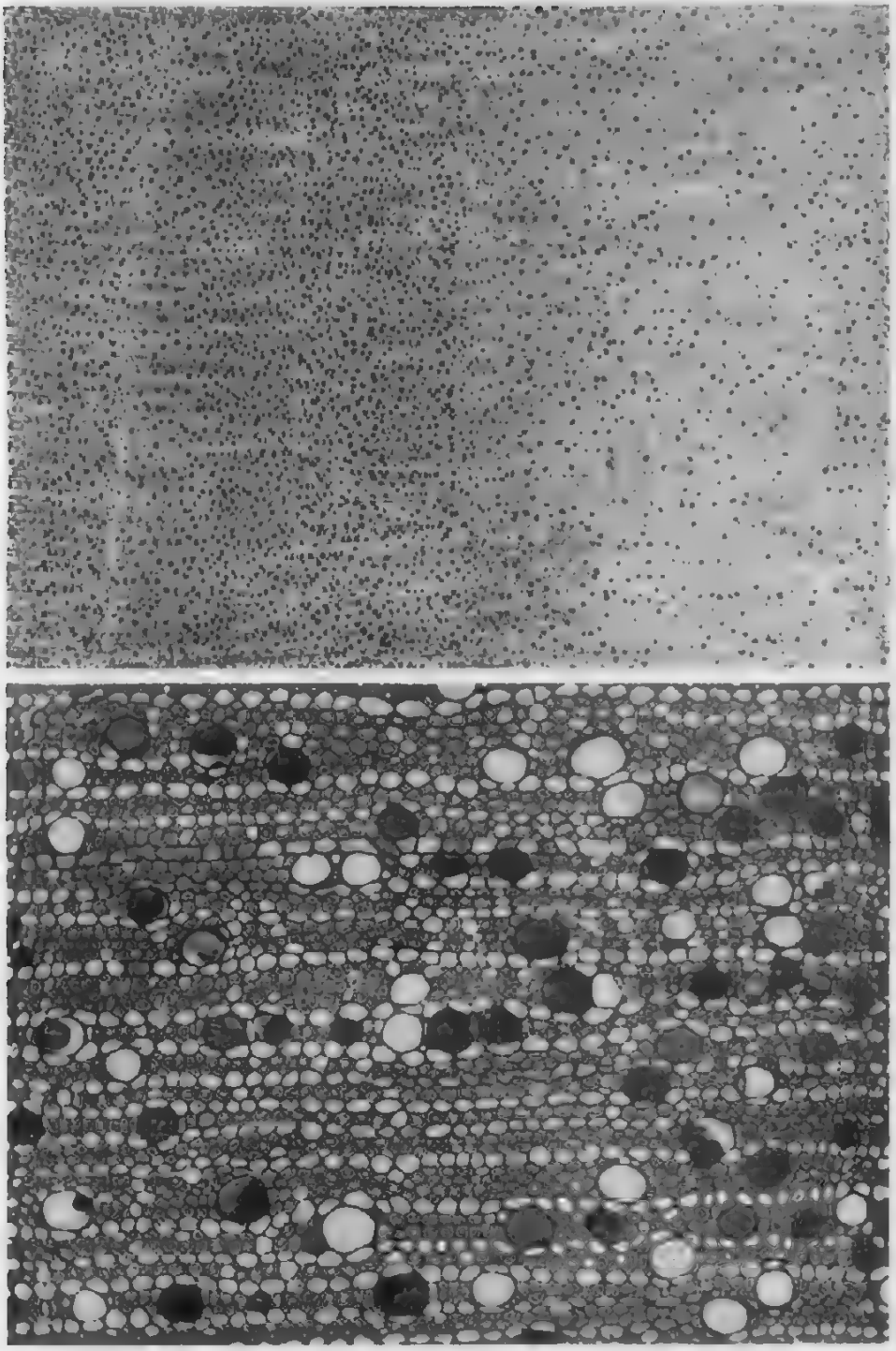

PLATE 24. SCYPHIPHORA HYDROPHYLLACEA GAERTN. F.

ANTHRACNOSE AND IMPORTANT INSECT PESTS OF THE MANGO IN THE PHILIPPINES, WITH A REPORT ON BLOSSOM-SPRAYING EXPERIMENTS

By MACARIO A. PALO[1]
Junior Mycologist, Bureau of Science, Manila

EIGHT PLATES

INTRODUCTION

The mango is the most important and the favorite dessert fruit in the Philippines. It has become very popular because of its aroma and its luscious richness of flavor. Some mango growers in the provinces around Manila not only have extended their orchards but also have established new plantations in order to keep pace with the growing demand for the fruit. As the industry flourishes, the planters are confronted with several troubles that greatly reduce their output. The situation of the mango industry at present is discouraging if no means be found to reduce the enormous discrepancy between the volume of inflorescences produced and the number of fruits that develop to maturity. Field studies and observations made in Batangas, Laguna, Rizal, and Bulacan Provinces have shown that this discrepancy may be attributed to many causes, among which the following are important: The low proportion of complete to staminate flowers on certain trees; the abundance of the hopper pest; the infestation of tip borers; the outbreak of anthracnose; the severity of fruit shedding; and weather factors which may affect the fertilization of the flowers injuriously.

The loss of the crop may be due to one or more of the above factors. In 1930 and 1931 the serious loss of the crop, particularly in Bulacan and Rizal Provinces, was due to a combination of three or more factors, with the hopper pest almost always

[1] The writer wishes to acknowledge the assistance of Dr. C. J. Humphrey, mycologist in charge of plant-disease investigations, Bureau of Science, under whose general supervision the work was carried out. He is also indebted to Dr. W. H. Brown, director, and to Dr. T. G. Fajardo, assistant pathologist, Bureau of Science, for valuable suggestions offered during the course of the work.

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gaining predominance. In December, 1930, many of the developing panicles of certain smudged trees in Quingua, Bulacan Province, were noted to have been seriously damaged by the tip borers. The inflorescences that were not destroyed by the tip borers were subsequently damaged by the mango hoppers, and a number of the few fruits that developed on the hopper-infested inflorescences showed the symptoms of anthracnose disease. Added to all these injurious factors was the occasional occurrence of rains which, at the time of blossoming, might affect fertilization injuriously.

FLOWERING HABITS OF THE PHILIPPINE VARIETIES OF THE MANGO AND THEIR RELATION TO PRODUCTION

In the Philippines knowledge of the flowering habits of mangoes is inadequate and is largely based upon general observations. The volume of flowering appears to be influenced by climatic conditions that prevail during the months immediately preceding the blooming season. It was generally observed that the occurrence of rainy weather in November, December, and January does not favor the production of a heavy flower flush in February and March. On the other hand, if these months are dry, the mangoes generally produce heavy inflorescences. This observation conforms to that of Ramachandra Rao(1) for the mangoes of southern India.

The blooming season usually does not exceed a period of three months; namely, February, March, and April. The heaviest flower flush occurs from the middle of February to the middle of March. It was observed occasionally that a few mango trees growing in dry places bear flowers as early as December and January, but the inflorescences produced during these months are relatively few. Likewise, the inflorescences produced in the last wave of flowering, which usually takes place in April but occasionally in May, are few; and many of the fruits that develop from them are abnormal in size and are of less commercial value. In the first wave of flowering many of the trees may be covered almost entirely with inflorescences. These exhaust them to such an extent that such trees frequently do not flower in succeeding months. The heaviest yield of mangoes is always obtained from the first wave of flowering.

It has been the practice in Bulacan Province and in some mango-growing sections of Rizal Province to force the trees to bear fruits off-season by smudging them from morning until evening for eight to twelve or more consecutive days. The

smudge is applied in October, November, and December to trees which are not in leaf flush. At Muntinlupa, Rizal Province, mango trees are sometimes smoked in December, January, and the early part of February. A tree that has been smudged properly frequently produces heavy inflorescence. Such trees do not generally flower again during the blooming season. On the other hand, if the smudged tree produces few inflorescences, it may flower profusely during the blooming period. Owing to the fact that smudging mango trees is done in the months during which pests and diseases are prevalent, generally not more than 10 per cent of those trees give a good harvest.

A normal mango inflorescence produces two kinds of flowers; namely, the staminate, which bear the male character, and the perfect or hermaphroditic, which bear both male and female elements. Although no actual count has been made, it may be presumed from observations of the flowering habits of the different varieties that the proportion of complete to staminate flowers may not be the same for all. In this connection, Popenoe(2) states that mango panicles vary from a few inches to 2 feet in length and carry from two hundred to more than four thousand flowers, of which, in some instances, 2 or 3 per cent are perfect, and in others 60 to 75 per cent. It is doubtful that the relative proportion of perfect to staminate flowers has any correlation with production, but from the theoretical point of view the trees that bear a greater number of complete flowers have a correspondingly greater chance to give a good harvest under equal conditions. This may perhaps be the reason why at Muntinlupa, Rizal, the pico and pahutan varieties produced a far greater number of fruits than the carabao variety when all of them were equally infested by hoppers. The pahutan variety retained as many as fifteen mature fruits, the pico variety up to ten, and the carabao variety generally one to four mature fruits on each panicle.

THE MANGO-HOPPER PROBLEM IN THE PHILIPPINES

The mango hopper is the worst pest of mango inflorescences. It is now of widespread economic importance. The enormous loss in the crops of 1930 and 1931 in practically all the mango-growing sections around Manila was due mainly to the severe infestation of this pest. The enormous loss occasioned by this pest came particularly to the writer's attention in March, 1930, when he observed a heavy destruction of inflorescences on about 50 per cent of the trees in the Hacienda Madrigal at Muntin-

lupa, Rizal Province, including all those that he sprayed with Bordeaux mixture and lime sulphur to protect the flowers from being attacked by anthracnose disease.

In the Philippines the life history of the leaf hoppers on mango inflorescence is not very well known. Specimens of the insects collected at Muntinlupa, Rizal Province, were sent to Dr. L. B. Uichanco, professor of entomology in the College of Agriculture, University of the Philippines, for identification. In his reply under date of July 15, 1931, Doctor Uichanco stated:

> There are two species in your lot. They are as follows: Order Homoptera, family Cicadellidæ, subfamily Bythoscopinæ.
>
> 1. *Idiocerus niveosparsus* Léthierry.—This is the large brown species, about 4.5 millimeters long.
>
> 2. *Idiocerus clypealis* Léthierry.—A much smaller species, only about 3.5 millimeters long, ground color light greenish. Judging from the relative numbers in your samples, it appears that this species is the more abundant of the two.

The greater bulk of the damage noted on the mango inflorescences in Muntinlupa, Rizal Province, is due to *I. clypealis* (Plate 1, fig. 2) since it is far more numerous than *I. niveosparsus* (Plate 1, fig. 1).

After the inflorescence buds have appeared and the developing panicles have grown out to a certain length, the hoppers begin to show their activity in laying eggs. Egg punctures may be noted on the flower stems and buds. Owing to the profuseness of egg laying of the hoppers, the inflorescences may wither and die before the opening of the flowers is completed. It seems as if the egg-laying activity of the hoppers is influenced by the climatic conditions prevailing in the locality. In November and December, 1930, the inflorescences produced by smudged trees in Bulacan Province, particularly in Quingua, Pulilan, and Baliuag, were seriously damaged, owing to the dense oviposition of the hoppers. At Muntinlupa, Rizal Province, it was noted that, owing to the heaviness of egg laying, more than 5 per cent of the developing panicles were heavily damaged during four or five days of cool, cloudy weather following a shower that occurred January 12, 1931. The inflorescences produced in the dry months of March and April, however, were but lightly damaged by the hoppers; consequently a fairly good harvest was obtained in June and July.

It was also observed at Muntinlupa in 1931 that two or more broods of the hoppers occurred before the flowers dropped off. One or two broods sometimes occurred before the opening of

the flowers, and another one or two broods during the blossoming period.

The nymph (Plate 1, fig. 3) feeds on the inflorescence by piercing the tissues with its proboscis and drawing the sap from them. In a severe infestation nymphs may occur by the hundreds or thousands on a single inflorescence, thereby causing it to appear blighted after a few days (Plate 1, fig. 4). When the infested inflorescence is agitated violently the nymphs on the flowers may be seen moving downward to hide on the lower parts of the twigs and lower surfaces of the leaves.

The hoppers excrete droplets of sticky, sweetish, amber-colored fluid known as "honey dew." In severe cases of infestation the inflorescences, as well as the leaves and twigs below them, are covered with this substance. The honey dew has an injurious effect upon the flowers since it prevents their fertilization to a certain extent and at the same time serves as a favorable medium for the growth of sooty mold (*Chaetothyrium mangiferae* Mendoza).[2] Within a brief period following rainy weather the growth of sooty mold on all parts of the tree covered with honey dew may become evident. The black growth of the mold on the leaves and peduncles (Plate 1, fig. 5) may persist until the fruits mature.

When there are no more flowers upon which the hoppers can feed, they migrate to the leaves. On the new leaf flushes, egg punctures made by the hoppers may again be noted on the midribs of leaves and a new hatching of the hoppers may occasionally be observed. In May, the adult hoppers, particularly *I. clypealis*, occur in great abundance on the leaves. Although their number had considerably decreased, still many of them were found on the leaves of a number of trees at Muntinlupa Plantation in July, August, September, and October, 1931. In the second half of September, 1931, when nearly 50 per cent of the trees in this plantation were in flush, egg punctures made by the hoppers were again noted on the midribs and petioles of the young leaves and occasionally on the tender stems. Probably the broods during this time were mostly *I. niveosparsus*, since when several nymphs of different stages were reared on a mango seedling inclosed in a celluloid cylinder with its top covered with cheesecloth, the adults that emerged from the last molting were in all cases *I. niveosparsus*.

[2] Determined by Mr. José Mendoza, associate mycologist, Bureau of Science.

THE ANTHRACNOSE DISEASE OF MANGO

Economic importance.—Anthracnose is the most important fungous disease of the mango. Its epidemic outbreak is largely influenced by high humidity so that in certain years it causes serious loss; in other years it is of practically little economic significance. Wester(3) claimed that "the failure of mango to set fruit may be due to excessive humidity or precipitation during the blooming period, but the cause is more probably the mango blight fungus, which was identified by P. H. Rolfs as *Colletotrichum glœosporioides* Penzig." In 1924, it was reported by the Philippine Bureau of Agriculture(4) to have caused a severe blossom-blight of mangoes in the Islands. Clara(5) describes the disease on the ripening fruits and states that it causes about 39 per cent of the storage decay in this fruit. In 1930 and 1931, anthracnose occurred in the mango-growing sections of Bulacan, Laguna, and Rizal Provinces, but the infection shown on the leaves and occasionally on the flowers and fruits was not severe enough to warrant serious attention. Although anthracnose infection may be light, its occurrence should be feared because it may serve as the source of a severe outbreak when the conditions for its development become favorable. The writer has noted but one instance of heavy anthracnose infection. This occurred on 60 per cent of nearly a thousand seedlings growing in beds beneath the mango trees at Muntinlupa, Rizal Province. A few of these seedlings died of the disease and the rest showed typical anthracnose spots on the leaves (Plate 2, fig. 1). Undoubtedly the trees that sheltered the seedlings served as the source of infection, as these showed symptoms of anthracnose on some of their leaves. The development of the disease on the seedlings was favored by the occurrence of rains, alternating with drizzles, over a period of four days (June 4 to 7, 1931). It may be inferred that the splashing of the rain on the diseased parts of the trees might have transferred the spores of the anthracnose organism to the seedlings beneath them.

Symptoms of the disease.—On the young leaves the incipient stage of the anthracnose disease may be recognized by the development of small, circular, vinaceous-brown [8] or deep brownish vinaceous spots. These spots develop slowly under dry-

[8] The colors indicated here and also in subsequent parts of this paper are those of Ridgway's Color Standards and Color Nomenclature. Washington (1912).

weather conditions. Under humid conditions they form large Mars brown or mummy brown blotches, causing the affected leaves to appear blighted (Plate 3, fig. 1). The blotches may become 20 to 50 millimeters in diameter (Plate 3, fig. 2); the tissues around the affected parts are deep olive-buff. White mycelial threads (Plate 2, fig. 2) and light ochraceous-buff to salmon-buff masses of spores may develop on the surface of the blotches under humid conditions. On the leaves the disease may be found commonly associated with injuries caused by scale insects, certain beetles, and midges. The midge larvæ mine the leaves and form small galls on them (Plate 3, fig. 4). After the larvæ have left the leaves, in order to pupate in the soil, the injuries caused by them on the leaves develop into spots and subsequently into shot holes (Plate 3, fig. 5). The anthracnose organism may frequently be isolated from such injuries.

Anthracnose attacks also the tender shoots and stems of seedlings, forming at first small, circular, or slightly oblong, spots (Plate 4, fig. 1), which may later develop into large dusky brown or blackish brown blotches. Wither tip (Plate 4, fig. 2) or die-back resulting from the attack of anthracnose is of rare occurrence. The drying of the young shoots is commonly a result of the merging together of the blotches which, in serious attacks, may cause the dying of all the tissues above the affected parts.

On the inflorescence the earliest recognizable symptoms of the disease is the production of blackish brown specks on the peduncles and flowers. In case of severe attack the flowers are distinctly blighted (Plate 3, fig. 3). This blighting is sometimes so very rapid that its incipient stages may escape observation. The infected flowers fall off, leaving the more-persistent spikes (Plate 3, fig. 6) on the peduncles.

Anthracnose attacks the young as well as the ripening fruits, but is rarely observed on pre-maturing ones. It is commonly observed blighting, and subsequently blackening, the newly-set fruits (Plate 4, fig. 3). Infection on these is believed to be a continuation of the progress of the disease on the flowers. The disease may also attack 20- to 30-day-old fruits, forming on the rind small, circular, blackish brown spots (Plate 4, fig. 4), which may merge together or enlarge into slightly depressed blotches (Plate 4, fig. 5). On the ripening fruit the disease occurs as sunken, blackish brown blotches upon which salmon-buff masses of spores develop (Plate 4, fig. 6).

Causal organism.—The anthracnose disease of mango is caused by the *Gloeosporium* stage of *Glomerella cingulata* (Stonem.) S. and v. S., of which there appear to be several strains of a single species.

Cultures of the organism from different isolations do not always display the same characters of mycelial growth even on the same medium. The growth may be flat or it may be slightly or largely aërial. It may be white or nigrescent. Some cultures are dark, while others are light or may assume various shades of gray. Again, some cultures develop abundant salmon-colored masses of spores; others produce few or none at all.

The fungus develops pustular acervuli on the diseased parts of the stem (Plate 6, fig. 4) and leaves. An acervulus (Plate 5, fig. 2) forms beneath the epidermis, and as it develops it ruptures the epidermis and exposes the spores. The conidiophores are hyaline, nearly filiform, and generally short. They generally arise from the stromatic layer of fungous structure. In culture they may also be borne either singly or as lateral outgrowths of the hyphæ (Plate 5, fig. 4) or in groups arising from a hyphal cell (Plate 5, fig. 6). Interspersed occasionally with the conidiophores in an acervulus are long, stiff, fuscous-black setæ (Plate 5, fig. 3). These are generally 2- to 3-septate, wider at the base and gradually tapering towards the tips. In some cultures they are produced abundantly, but in others they are either few or entirely lacking. The spores are borne on the tips of the conidiophores. They are single celled, hyaline, and elliptical to oblong (Plate 5, fig. 5). From various culture media they measure 8.3 to 27.4 μ in length and 2.0 to 6.6 μ in width. On the average they are 14.2 μ long and 4.4 μ wide. They are finely and uniformly granular while young, but with age they become prominently vacuolate. They are produced in masses on the surface of the lesions and may behave likewise on the culture medium. Since they adhere to one another, they are not well adapted to wind dissemination. Some cultures isolated from mango produce black, stromatoid bodies (Plate 5, fig. 1), which when sectioned show nothing but a mass of interlaced hyphæ.

When a number of mango seedlings in leaf flush were sprayed with a spore suspension, the symptoms of anthracnose disease were produced on the young leaves (Plate 6, fig. 3) and occasionally on the tender stems. The control seedlings remained clean and healthy. Under greenhouse conditions and in the presence of much moisture the disease causes the blighting of

the young leaves of the inoculated seedlings within four days. It may spread downward to the stem, upon which are developed numerous acervuli (Plate 6, fig. 4) and abundant masses of spores.

OBSERVATIONS ON THE FRUIT SHEDDING OF MANGOES AT MUNTINLUPA, RIZAL PROVINCE

The shedding of mango fruits at Muntinlupa was severe in 1931. It is estimated that not more than 5 per cent of the newly-set fruits on certain trees reached maturity, the greatest amount of fruit fall taking place before the fruits attained a length of 30 millimeters. It then gradually decreased as the fruit approached maturity. The first to fall were the unfertilized pistils, and also those weakened by the hoppers. This was followed by a number attacked by anthracnose and by a few spotted and mummified fruits (Plate 4, fig. 7), the cause of which is still unknown. This unknown trouble was at first mistaken for anthracnose, but tissue isolations from the diseased parts of the fruits were all negative. A number of the diseased fruits were placed in a moist chamber but, again, no fungous growth developed on the lesions.

The great majority of the fruits that were shed within twenty-five to thirty days after setting appeared normal. They did not show any evident fungous lesion or insect injury. It was noted in one instance that as many as fifty-two young fruits of the pico variety were counted on a single panicle, but after a month only two were left to mature. The rest were weeded out. This phenomenon of natural thinning out of the fruits is believed to be a physiological trouble. Popenoe(2) in his studies of mango sterility has concluded that the problem is a physiological one, connected with nutritional conditions, as influenced by changes in soil moisture and food supply, principally the former. Ramachandra Rao(1) reports that the deficient soil nutrition, coupled with adverse climatic factors, such as the dry season, while the mangoes are in blossom do not allow sufficient nourishment for a great number of fruits, and consequently many are weeded out. He supported this idea by observational evidence, stating that the trees are able to retain a larger number of fruits if good summer rains are received, if irrigation is given after the fruits have set, and if the soil-moisture is assured by suitable cultural methods.

Another physiological cause of fruit fall of mangoes is the cracking of pre-maturing and maturing fruits. These cracks

are generally longitudinal (Plate 6, fig. 1). They appear dry, with the exception, in some cases, of a flow of a small amount of sap coming from the injured tissues. Rot organisms invade these injured tissues and cause them to fall away.

A number of fruits may also shed owing to the attack of caterpillars which bore into them. The pest may be recognized by the presence of an exudate coming from the wound made by the caterpillar, which as it progresses covers itself with excrement and refuse. The occurrence of maggots in a few fruits showed that certain flies bred in them. The maggots entered perhaps through bruises on the rind. The injuries made by both the caterpillars and maggots favor the development of rot organisms and the fruits subsequently rot and fall away.

MANGO TIP BORER ANOTHER FACTOR OF LOSS

The mango tip borer[4] (*Chlumetia transversa* Walker) is widespread in all the central and southern provinces of Luzon. It was noted to have caused damage to about 25 per cent of the inflorescences on certain trees in the Barrio of Dampol in Quingua, Bulacan Province. On other trees the infestation was so light that sometimes only 0.5 per cent of the total volume of inflorescence was damaged. At Muntinlupa, Rizal Province, it damaged on the average about 10 per cent of the panicles that developed on trees smudged in January, and about 2 to 4 per cent of the panicles produced during the normal blooming season.

The injury is produced by the larva, which enters at or about the apices of the developing panicles and then tunnels its way into the central part, forming a cavity in it and causing the upper spikes and spikelets to shrivel and dry. If it tunnels its way down to the base of the panicle the entire inflorescence may die. This pest attacks also the young shoots (Plate 6, fig. 2) of the new flushes, causing the shrivelling and drying of the top parts. The dying of the shoots means a reduction of the flowering area in the succeeding blooming period. September 25, 1931, the tip-borer-infested young shoots in every hundred counted on one portion of each of the twelve trees in flush at Muntinlupa Plantation varied from 11 to 50 per cent, with an average of 29 per cent.

[4] Mr. Pedro Sison, assistant entomologist of the Bureau of Plant Industry, is familiar with this pest. He informed me that it is the larva of *Chlumetia transversa* Walker.

PRELIMINARY REPORT ON MANGO-BLOSSOM SPRAYING EXPERIMENTS AT MUNTINLUPA, RIZAL PROVINCE

SPRAYING EXPERIMENTS OF 1930

The first spraying experiments were conducted in February and March to determine three points; namely, the efficacy of Bordeaux-mixture and lime-sulphur sprays in preventing anthracnose infection on the inflorescences, the strength of spray necessary to obtain the desired results, and when to apply the spray and the intervals between applications. Trees that showed anthracnose disease on the foliage were selected for these experiments. The sprays were applied with a bucket spray pump fitted with an 18-meter hose. An effort was made to cover the leaves and panicles with a thin coating of the sprays. While the experiments were progressing the inflorescences of the sprayed trees were unexpectedly attacked severely by hoppers when the flowers were beginning to open. As a result, the inflorescences of the treated and the check trees were equally damaged. However, a few things were learned from these experiments. It was found that lime sulphur in a dilution of 1 : 50 up to 1 : 30 and Bordeaux mixture in strengths of 2 : 4 : 50, 3 : 4 : 50, and 4 : 4 : 50 do not have any injurious effect upon the mango inflorescences if given before the opening of the flowers.

SPRAYING EXPERIMENTS OF 1931

Condition of the smudged trees in flower before the spraying experiments of 1931 were started.—In December, 1930, a trip was made to Muntinlupa, Rizal, with the view to securing additional data on the hopper infestation in that locality. A few smudged trees were in flower. It was noted that the hoppers occurred in great abundance on the inflorescences. The tip-borers which formed cavities in the panicles were also noted to have shared prominently in the destruction of the inflorescences. Anthracnose occurred also, and, although the infection was light, it was feared that it might become a source of a severe outbreak under favorable weather conditions. Owing to the fact that the inflorescences which had been smudged in December were damaged by a variety of factors, the use of combination sprays in subsequent experiments was resorted to so as to bring as many of those factors under control as possible.

Methods of spraying.—The spraying experiments were conducted in an orchard at Hacienda Madrigal in Muntinlupa, Rizal,

from January to March, but the observations were continued until July. The orchard consisted of a mixture of carabao, pico, and pahutan varieties. The trees, which were about a hundred in number, were all normally bearing and varied from 10 to 15 meters in height, with crowns 11 to 18 meters in diameter. About sixty trees in this orchard were forced to bear flowers by smudging. Trees of the carabao variety which showed a more or less uniform distribution of the inflorescence buds on their crowns were used. The sprays were applied over an experimental area of 15 to 25 square meters on each tree. The other portions of the crown were used as controls.

The spraying outfit consisted of a Gould's New Combination Hand Sprayer No. 1640 with a 9-meter hose, the nozzle of which was tied to a light 4-meter bamboo rod. Two laborers were required in spraying, one operating the pump, which was mounted on a stage made of wood, and the other applying the spray to the inflorescences, leaves, and twigs. The higher parts of the side branches were sprayed with the aid of the bamboo rod and a 3-meter bamboo ladder provided with props.

Bordeaux mixture and lime sulphur were the principal sprays used, but to these were added either nicotine sulphate or lead arsenate, or both, for the control of insects. Chinese soap and nicotine sulphate were also introduced in the Bordeaux-mixture series.

A clue as to the best time of application developed from a preliminary trial in which the writer failed to prevent severe infestation of hoppers by spraying weekly two mango trees of the pico variety with 3:4:50 Bordeaux mixture to which nicotine sulphate (Blackleaf 40) was added at the rate of 1 to 800 parts of the spray. In this preliminary trial the inflorescences (Plate 7, fig. 1) appeared healthy until the third spraying despite the fact that they were slightly weakened by the abundant egg-laying of the hoppers. The spray did not show any burning effect upon the flowers (Plate 7, fig. 2). The eggs of the hoppers began to hatch a day after the third spraying, and within three days after the appearance of the first hatching the flowers were found swarming with the nymphs of the hoppers, the majority of the inflorescences being severely damaged before the date of the fourth spraying. The inflorescences which were partially damaged developed young fruits only on their apices after the fifth spraying. Nearly all of the inflorescences of the control tree were damaged. One of these inflorescences is

shown in Plate 7, fig. 3. Two things were shown in this trial; namely, that Bordeaux-nicotine sulphate is useless as a spray for the adult hoppers, and that weekly sprayings may not prevent a severe infestation of the hoppers, especially if new hatchings of the hoppers occur immediately after the application of the spray. Having known that weekly sprayings will not help much in preventing severe infestation of the hopper nymphs, it was then planned to apply the spray containing the nicotine sulphate while the new broods were hatching.

In subsequent sprayings (Table 1), in which Bordeaux mixture was the chief fungicide, five applications were made as follows:

1. A preliminary spray of 5 : 5 : 50 Bordeaux mixture, to which lead arsenate powder (1.5 pounds to 50 gallons of Bordeaux mixture) was added, was given when the inflorescence buds were bursting, in order to protect the developing panicles from an early attack of anthracnose and tip borers.
2. A second spray of 3 : 4 : 50 Bordeaux mixture, to which nicotine sulphate (1 to 800 parts of the spray) and lead arsenate powder (0.8 pound to 50 gallons of the mixture) were added, was given before the opening of the flowers, to prevent further attack of anthracnose and tip borers, and also the hoppers, in case a brood occurred within this period.
3. A thorough spray of nicotine-soap solution was given when a new brood of the hoppers was noticed.
4. The third spray was repeated within three to six days when further hatchings were noticeable.
5. The fifth spray consisted of a repetition of the second spray. It was given when the petals were withering, in order to protect the young fruits from the attack of anthracnose, hoppers, and certain insects.

In a second series (Table 2) lime sulphur, which has both fungicidal and insecticidal properties, was used instead of Bordeaux mixture to prevent anthracnose infection. In this series four sprayings were made as follows:

1. A preliminary spray of lime sulphur, 3° Beaumé, to which lead arsenate powder (1.5 pounds to 50 gallons of lime-sulphur spray) was added, was given while the inflorescence buds were bursting, in order to protect the developing panicles from the attack of anthracnose and tip borers.
2. A second spray of lime sulphur, 1.28° Beaumé, to which nicotine sulphate (1 to 800 parts of lime-sulphur spray) and lead arsenate (0.8 pound to 50 gallons) were added, was given before the flowers began to open, or when the first brood of the hoppers occurred.
3. A third spray of lime sulphur-nicotine sulphate was given when further hatchings were noticed.
4. The last spray was the same as the second. It was given when all of the flowers had opened.

TABLE 1.—*Schedule and results of spraying the inflorescences of carabao mango trees for hoppers, tip borers, and anthracnose, using strong Bordeaux-lead arsenate as the preliminary spray.*

	Tree No.								Average for all trees.
	1	2	3	4	5	6	7	8	
Treatments and dates of applications:									
First spraying—									
Bordeaux mixture (5:5:50), 50 gallons. Lead arsenate powder, 1.5 pounds	Jan. 19	Feb. 1	Feb. 1	Feb. 10	Feb. 19	Feb. 24	Feb. 24	Feb. 24	
Second spraying—									
Bordeaux mixture (3:4:50), 50 gallons. Nicotine sulphate (blackleaf 40) 0.625 pound. Lead arsenate powder, 0.8 pound	Jan. 31	Feb. 11	Feb. 11	Feb. 19	Mar. 1	Mar. 6	Mar. 6	Mar. 6	
Third spraying—									
Chinese soap, 1.5 pounds. Nicotine sulphate (blackleaf 40), 0.625 pound	Feb. 4	Feb. 15	Feb. 15	Feb. 24	Mar. 6	Mar. 11	Mar. 12	Mar. 10	
Fourth spraying—									
As in the third spraying	Feb. 9	Feb. 20	Feb. 20	Feb. 28	Mar. 9	Mar. 15	Mar. 15	Mar. 15	
Fifth spraying—									
As in the second spraying	Feb. 13	Feb. 25	Feb. 25	Mar. 3	Mar. 12	Mar. 20	Mar. 20	Mar. 20	
Number of mature fruits produced on 3-square-meter portions of the crown:									
Totals—									
Treated	76-29-43 51-24-41	19-14-17	19-34-30	93-36-46	45-29-42	12-17-30	14- 8- 8	6- 3- 0	
Checks	7-10- 5 0- 3- 4	4- 6- 2	7- 2- 7 3- 2	8- 0-11 12- 8	6- 9-4-4	0- 0- 0	1- 0- 0	0- 0- 0	
Average—									
Treated	44.0	16.6	27.6	55.0	38.6	19.6	10.0	3.0	26.8
Checks	4.8	4.0	4.2	7.8	5.7	0.0	0.3	0.0	3.35
Weather observations	(a)		(b)	(c)	(d)				

[a] January 29. Continuous shower at dawn followed by a drizzle in the forenoon.
[b] February 12. Shower for about half an hour. Day cloudy and cool.
[c] February 23. Shower for about two hours.
[d] March 19. Continuous shower from midnight, followed by heavy rain in the morning and then followed by continuous shower until midday.

TABLE 2.—*Schedule and results of spraying the inflorescences of carabao mango trees for hoppers, tip borers, and anthracnose, using strong lime sulphur-lead arsenate as the preliminary spray.*

	Tree No.									Average for all trees.
	9	10	11	12	13	14	15	16	17	
Treatments and dates of applications:										
First spraying—										
Lime sulphur (30° Beaumé), 50 gallons. Lead arsenate powder, 1.5 pound	Feb. 3	Feb. 3	Feb. 14	Feb. 25	Feb. 25	Mar. 2	Mar. 2	Mar. 2	Mar. 1	----
Second spraying—										
Lime sulphur (1.28° Beaumé), 50 gallons. Nicotine sulphate (blackleaf 40) 0.625 pound. Lead arsenate powder, 0.8 pound	Feb. 17	Feb. 17	Feb. 24	Mar. 6	Mar. 6	Mar 12	Mar. 12	Mar. 12	Mar. 14	----
Third spraying—										
Lime sulphur (1.28° Beaumé), 50 gallons. Nicotine sulphate (blackleaf 40), 0.625 pound	Feb. 21	Feb. 24	Feb. 28	Mar. 16	Mar. 16	Mar. 16	Mar. 16	Mar. 16	Mar. 17	----
Fourth spraying—										
As in the second spraying	Feb. 25	Mar. 1	Mar. 5	Mar. 20	Mar. 20	Mar. 20	Mar. 20	Mar. 20	Mar. 20	----
Number of mature fruits produced on 3-square-meter portions of the crown:										
Totals—										
Treated	30–30–13	25–32–33	43–55 45–52	12–10	8–10	12–14	17–14	15–14	19–22–19	----
Checks	0–5–0–3	8– 0–3–5	5– 0– 2 7– 5– 4	0–0	0–0	1–0–1	0–2–0–2	2–1–0	0–0–2	----
Average—										
Treated	24.3	30.0	48.7	11.0	9.0	13.0	15.5	14.5	20.0	20.7
Checks	2.0	4.0	3.8	0.0	0.0	0.6	1.0	1.0	0.6	1.4
Weather observations	[a]	----	[b]	----	[c]	----	----	----	----	----

[a] February 12. Shower for about half an hour. Day cloudy and cool.
[b] February 23. Shower for about two hours.
[c] March 19. Continuous shower from midnight, followed by heavy rain in the morning, then followed by continuous shower until midday.

After the third spraying (Tables 1 and 2) one hundred panicles on one sprayed section and another hundred on one control section of each tree were counted and the number of tip-borer-infested inflorescences recorded. The results of these counts are given in Table 3.

TABLE 3.—*Showing the number of tip-borer-infested panicles in every hundred counted on the control and sprayed parts of each tree.*

Trees in the first series (Table 1).			Trees in the second series (Table 2).		
Tree No.	Treated.	Controls.	Tree No.	Treated.	Controls.
1	5	11	9	0	4
2	0	2	10	5	13
3	3	5	11	4	4
4	5	4	12	4	6
5	2	8	13	4	2
6	7	10	14	1	0
7	6	4	15	3	8
8	2	5	16	5	6
			17	3	8
Average	3.7	6.1	Average	3.2	5.1

As the inflorescences developed they were examined from time to time for the occurrence of new hatchings of the hoppers and for anthracnose, while a number of both the inflorescences and fruits that developed from the control and sprayed sections of each tree were brought to the laboratory for further studies and isolation of the anthracnose organism.

Weather conditions at the time of spraying are recorded in Tables 1 and 2.

The comparative yield of the sprayed and control parts of each tree was determined when the fruits matured. This was done by placing at random a 3-square-meter circle, made of bamboo, over the sprayed and unsprayed parts of each tree, the fruits inclosed by the circle being counted. The fruits produced within the crown and which lay within the horizontal level of the circle were also counted. The results of these counts are given in Tables 1 and 2.

DISCUSSION OF THE SPRAYING EXPERIMENTS OF 1931

The use of lead arsenate in combination with Bordeaux mixture (Table 1) or with lime sulphur (Table 2) appears to be of little value as a control for the tip-borer pest on the panicles. The first two sprayings shown in Tables 1 and 2 were given during the period of rapid growth of the panicles and the failure of lead arsenate to control the tip-borer pest was perhaps due

to the fact that as the panicles elongated there were numerous points which were not covered by the spray, and the larvæ of the tip-borer pest might have entered through these unprotected parts. It is also doubtful whether or not the use of lead arsenate in the first and second sprayings (Tables 1 and 2) reduced materially the tip-borer injury, although on the average a reduction from 6.1 to 3.7 per cent is shown in Table 3 and from 5.1 to 3.2 per cent in Table 4. The results given in Tables 3 and 4 are uncertain because trees 4 and 7 in Table 3 and trees 13 and 14 in Table 4 showed a greater number of infested panicles on the sprayed than on the control portions. Furthermore, trees 11 and 17 in Table 4 showed an equal number of infested panicles on the sprayed and control parts. These results might even be accounted for by the unevenness of the distribution of the tip-borer pest in the tree.

The first two sprayings (Tables 1 and 2) were of no value in preventing the adult hoppers from laying eggs on the developing panicles. Egg punctures were noted on the flower stems and buds. The first brood of the hoppers occurred frequently before the opening of the flowers, since the spraying had no effect on the eggs. On some trees it occurred when the flowers were beginning to open. The second and third broods occurred generally during the blossoming period. The application of the second spray (Tables 1 and 2) was found to have killed the nymphs of the first brood except those which were not covered by the spray. It was observed that when the spray disturbed the panicles, the nymphs began to move downward to the twigs and those that were missed by the spray were found hiding beneath the leaves. This behavior of the nymphs necessitates a thorough application of the spray, not only to the inflorescences but also to the leaves and twigs. When the spray containing nicotine sulphate covered the soft bodies of the nymphs they were killed almost immediately. The third and fourth sprays (Tables 1 and 2) were found fairly efficient in killing the nymphs of the second and third broods. Nicotine-soap solution as the third and fourth sprays (Table 1) was also noted to be very effective in killing the nymphs.

Although the sprays containing nicotine sulphate in Tables 1 and 2 were effective in killing the nymphs of the hopper, they only partially reduced the damage done by this pest, since the adult hoppers weakened the tissues of the panicles by withdrawing a quantity of sap and making egg punctures in them,

and the spray not being applied until two to three days after the appearance of the new hatchings permitted the nymphs from the early-hatched eggs to feed on the inflorescences during this interval. Although the application of the spray seemed to be thorough, there were still some nymphs that were not covered by the spray. Likewise, when it rained hard, nymphs from the upper, unsprayed portions of the crown probably migrated and perhaps a few were washed down to the treated portions. This happened on the treated portions of trees 6, 7, and 8 in Table 1 and on trees 12, 13, 14, 15, 16, and 17 in Table 2. These trees were in blossom and their sprayed parts were almost free from hoppers before the heavy rain of March 19 occurred. Numerous nymphs of different stages were then noted on the sprayed sections after the rain had ceased. The treated parts were sprayed again March 20, at which time the nymphs had fed for about twenty-four hours. Despite the treatment that was given on this day the flowers were severely damaged, but the damage on the sprayed parts could not be attributed solely to the nymphs, since they fed on the inflorescences for only twenty-four hours. It was, therefore, presumed that the rain of March 19 might have had an injurious effect upon the fertilization of the complete flowers. Few fruits developed to maturity on the sprayed parts of the trees. The unsprayed portions were almost totally ruined. Likewise, the treated parts of trees 2 and 3 in Table 1 and trees 9 and 10 in Table 2 suffered great damage when the shower which continued for two hours February 23 occurred while they were in blossom. It may be noted in Tables 1 and 2 that the showers of February 12 and February 23 did not damage to any great extent the sprayed parts of trees 1, 4, and 5 in Table 1 and tree 11 in Table 2, owing perhaps to the fact that the rains occurred before these trees were in blossom. The sprayed portions of these trees produced a far greater number of fruits than those of other trees.

It is not certain whether the use of Bordeaux mixture (Table 1) and lime sulphur (Table 2) prevented anthracnose infection on the inflorescences. The sprayed portions of the trees in Tables 1 and 2 did not show the symptoms of anthracnose disease; but owing to the difficulty of diagnosing anthracnose disease on the hopper-infested inflorescences, it is not known whether or not the controls were attacked by this disease. Several attempts were made to isolate the anthracnose organism from the hopper-infested inflorescences, but the organisms that grew in the culture plates were mostly molds, *Acrothecium* and

Pestalozzia. However, the symptoms of anthracnose were noted on a number of young fruits as well as those up to 20 or 30 days old (Plate 4, figs. 3, 4, and 5). The infection was so light, however, that they were observed only on one tree. On the other trees the disease was not noted. Since anthracnose infection on inflorescences and fruits was not general in the orchard its absence on the sprayed parts of the trees under experiment was not strange.

Again it would be difficult to ascertain which of the two spray programs (Tables 1 and 2) gave the best results against the various agents concerned, because not all of the trees used in both series blossomed at the same time; consequently, the blossoms were not exposed to the same climatic influences. In Table 1 only three trees had their blossoms exposed to the bad weather of March 19, while in Table 2, six trees were exposed; thus, a lower average yield was obtained in Table 2 than in Table 1. Both procedures seem to be highly beneficial if no rains occur during the blossoming period to damage the inflorescence. The sprayed part of tree 1 (Plate 8, fig. 1) in Table 1 and tree 11 (Plate 8, fig. 2) in Table 2 produced a fairly good crop, owing perhaps to the fact that no rain occurred while the trees were in blossom. The unsprayed portions generally gave a poor harvest. Tree 11 (Plate 8, fig. 2) shows the development of a few fruits on its upper unsprayed portion. Comparing the average yield of the treated trees with the controls in Tables 1 and 2, it may be inferred that the increase in yield of the treated portions over the control portions is due to the beneficial effect of spraying.

COST OF SPRAYING

It was computed that the cost of spraying a tree with a crown of approximately 100 square meters,[5] following the program given in Table 1, would be 12.02 pesos—10.02 pesos for the sprays and 2 pesos for labor. Following the program in Table 2 it would cost 9.48 pesos to spray the same tree.

PROFIT THAT MIGHT BE REALIZED IN SPRAYING MANGO TREES OF THE CARABAO VARIETY UNDER THE CONDITIONS THAT EXISTED DURING THE COURSE OF THE INVESTIGATION

In Table 1, the average yield on 3-square-meter portions of the crown is 26.8 fruits for the treated and 3.4 fruits for the

[5] A tree with a crown of 100 square meters is not far from an average-sized tree in the orchard where this spraying investigation was conducted.

checks. Computing from these data, a sprayed tree with crown of 100 square meters would yield 893 fruits or 6 *kaings*.[a] If the same tree were not sprayed, it would yield 113 fruits, or less than 1 kaing. The price of carabao mangoes in the market varies according to the months in which they are harvested. Before the end of April a kaing of carabao mangoes costs 8 pesos or more. This price gradually falls until a kaing costs only 5 pesos at about the end of May and 2.50 to 4 pesos in June. Then it gradually rises again until the harvest period ends. Taking 5 pesos as an average price of one kaing of carabao mangoes, the profit that may be realized in spraying a tree with crown of 100 square meters may be computed as follows:

	Pesos.	Pesos.
Value of 6 kaings	30.00	.....
Cost of spraying	.....	12.02
Cost of smudging[a]	.....	4.00
Cost of picking 6 kaings of mangoes[b]	.....	0.48
Net returns	.....	13.50
	30.00	30.00

[a] Smudging mango trees is done within an average of ten consecutive days. A laborer working at 80 centavos a day can smudge two trees within this period.

[b] A laborer working at 80 centavos a day can pick on the average 10 kaings.

Following the above computation the same tree if treated according to Table 2 would give net returns of 9.12 pesos. If the tree were unsprayed, there would be a net loss of approximately 32 centavos per tree according to the following computation:

	Pesos.	Pesos.
Value of 0.75 kaing (113 fruits)[a]	3.76	.....
Cost of smudging	.....	4.00
Cost of picking	.....	0.08
Net loss	0.32	.....
	4.08	4.08

[a] Computed from the average yield for all checks in Table 1.

The above data are in accord with the general observation of the people who saw the conditions of the orchard and with the statement of Mr. Ambrosio Reyes, overseer of Hacienda

[a] A "kaing" is a bamboo basket used for marketing mangoes. According to Mr. Ambrosio Reyes, overseer of Hacienda Madrigal at Muntinlupa, Rizal, a kaing contains on the average 150 fruits of the carabao variety. Director Stanton Youngberg, of the Philippine Bureau of Agriculture, states in his annual report for the year 1928 that a kaing contains approximately 124 fruits of the same variety.

Madrigal, that the trees of the carabao variety which were smudged, but not sprayed, this year (1931) at the hacienda did not give sufficient returns to cover the expenses for labor; only a number of trees of the pico variety which were smudged in the first half of February, gave a fairly good harvest.

A further proof that spraying is practicable may be mentioned. 'A trial was made in which the entire crown of a smudged carabao tree was sprayed according to Table 1. The tree was sprayed January 19, January 31, February 4, February 10, and February 14. Another smudged carabao tree of practically the same size and equal volume of inflorescence was used as control. The fruits were harvested in the latter part of April. The control tree yielded nearly 2 kaings and the sprayed tree more than 10 kaings. The price of mangoes at this time was 8 pesos a kaing. It cost 13.82 pesos to spray and 4 pesos to smudge the tree. Eighty centavos were spent for picking the mangoes from the sprayed tree and 16 centavos from the unsprayed one. A net profit of 61.38 pesos was thus realized from this single sprayed tree as against 11.84 pesos for the unsprayed, the difference of 49.50 pesos being clear gain.

SUMMARY

1. The great loss in the mango crop in the Philippines is due to a combination of several factors, among which the following are important: Abundance of the hopper pest, infestation of tip borers, severity of fruit shedding, outbreak of anthracnose, and occurrence of rains during the blossoming time.

2. The hopper pest has been noted to be the most important. In severe cases nearly all the inflorescences on a tree may be damaged. Two species of leaf hoppers on the inflorescence have been recognized. The large brown species, about 4.5 millimeters long, is *Idiocerus niveosparsus* Léthierry. A much smaller species, only about 3.5 millimeters long, ground color light greenish, is *I. clypealis* Léthierry. *Idiocerus clypealis* is more destructive than *I. niveosparsus* owing to its great abundance. The hoppers destroy the inflorescences by (*a*) making egg punctures on them, (*b*) drawing the sap from the tissues, and (*c*) excreting sticky, sweetish "honey dew" which favors the growth of sooty mold and prevents the fertilization of complete flowers to a certain extent. Two or more hatchings of the hoppers occur during the life of the inflorescence. The nymphal stage is the most destructive part in the life cycle.

3. Anthracnose is the most important fungous disease. High humidity increases the severity of attack. On the young leaves, it forms vinaceous brown or deep brownish vinaceous spots which may develop into large Mars brown or mummy brown blotches under humid conditions. It develops blackish brown spots on the flowers, fruits, and young shoots. It is also found commonly associated with insect injuries on the leaves. It is caused by the *Gloeosporium* stage of *Glomerella cingulata* (Stonem.) S. and v. S., which organism has also been found pathogenic on the young leaves and tender stems of mango seedlings.

4. Fruit shedding of mangoes is serious in Muntinlupa, Rizal Province. It is caused by various agencies but, since the majority of the shed fruits appear healthy, the trouble has been regarded as primarily physiological.

5. The tip-borer pest (*Chlumetia transversa* Walker) tunnels the panicles and young shoots of mango causing them to shrivel and dry.

6. In spraying experiments conducted at Muntinlupa, Rizal Province, on trees infested with hoppers and tip borers, and lightly attacked by anthracnose disease, spraying increased the yield of the treated trees from eight to fourteen times over the control. The first spraying consisted of: (*a*) A preliminary application of rather strong Bordeaux-lead arsenate given while the inflorescence buds were bursting. (*b*) A second spray of weaker Bordeaux mixture to which nicotine-sulphate and lead arsenate were added. (*c*) A third spray of nicotine-soap solution when a new brood of the hopper was noticed, and repeated at intervals of three to six days when further hatchings were observed. (*d*) Another spray of Bordeaux mixture-nicotine sulphate-lead arsenate when the petals were withering. The second set of tests consisted of: (*a*) A preliminary spray of lime sulphur 3° Beaumé to which lead arsenate was added, this being applied when the inflorescence buds were bursting. (*b*) A thorough spray of lime sulphur, 1.28° Beaumé, to which nicotine-sulphate and lead arsenate were added, applied on the appearance of the first brood of the hoppers, and repeated when further hatchings were noticed. (*c*) Another spray of lime sulphur-lead arsenate when the petals were withering.

The results obtained in the use of Bordeaux mixture and lime sulphur in both series did not prove conclusively that they can fully prevent the attack of anthracnose on the inflorescence. Likewise, it was also not certain that the number of tip borers

had been reduced by lead arsenate used in combination with the first and second sprays. The use of nicotine-sulphate in both series proved effective in reducing the damage by hoppers. Both preliminary spray series increased the yield from eight to fourteen fold and in the 1931 experiments led to a good net profit, whereas unsprayed trees handled at a loss.

Further experiments must be carried out, however, under less-favorable climatic conditions before safe generalizations can be made.

It is also very probable that the spray procedure can be considerably simplified and still yield good returns.

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ILLUSTRATIONS

PLATE 1

FIG. 1. *Idiocerus niveosparsus* Léthierry, adult stage; about × 2.
2. *Idiocerus clypealis* Léthierry, adult stage; about × 2.
3. *Idiocerus clypealis*, nymphs; about × 2.
4. A hopper-infested inflorescence showing the blighted flowers; about × 2/5.
5. A mango twig from a hopper-infested tree showing the growth of sooty mold on the leaves and peduncle that have been previously coated with the excrement ("honey dew") of the hoppers; about × 1/3.

PLATE 2

FIG. 1. A mango seedling taken from a bed of about one thousand seedlings, 60 per cent of which showed anthracnose disease. Note the numerous small, circular, vinaceous brown spots on the leaves and lower portion of the stem; about × 0.5.
2. A portion of a mango leaf collected in Solano, Nueva Vizcaya Province, showing the symptoms of anthracnose and also the mycelial growth of the causal fungus on the surface of the lesions. Beneath the growth are numerous, slimy, salmon buff masses of spores of the causal organism; about × 0.5.

PLATE 3

FIG. 1. Mango leaves blighted by anthracnose disease; about × 8/15.
2. A mango leaf showing large anthracnose blotches; about × 8/15.
3. Mango spikes showing a few flowers blighted by the anthracnose organism; natural size.
4. A portion of a mango leaf showing small galls caused by larvæ of the midge; nearly natural size.
5. A mango leaf showing spots and shot holes which have been primarily caused by the larvæ of the midge, with which the anthracnose organism may be associated; × 0.5.
6. Mango spikes whose flowers have dropped off owing to the attack of anthracnose. Note the anthracnose spots on them; × 2/3.

PLATE 4

FIG. 1. Stems of mango seedlings showing the early stage of anthracnose infection. Note small, circular, blackish brown spots on the stems; about × 2/3.
2. A case of a severe anthracnose disease on the stem of a young mango shoot. The leaves withered as a result of the attack; about × 2/3.

FIG. 3. Anthracnose on the young fruits and flowers of mango. Small masses of spores of the causal fungus have developed on one of the fruits; about × 2/3.

4. A 30-day-old mango fruit showing the early stage of anthracnose disease characterized by the development of small, circular, blackish brown spots; about × 2/3.
5. A 20-day-old mango fruit showing large blackish brown anthracnose spots upon which numerous small masses of spores of the causal fungus have developed; about × 2/3.
6. A ripening fruit of the carabao variety showing large, sunken, blackish brown blotches upon which may be noted the development of numerous masses of spores of the causal fungus; about × 2/3.
7. A mango twig bearing spotted and mummified young fruits, the cause of which is still unknown; about × 0.5.

PLATE 5

FIG. 1. A black stromatoid body from a 20-day-old potato-glucose-agar culture of the anthracnose organism isolated from mango flowers collected in Singalong, Manila; × 533.

2. A section through an acervulus that developed on the stem of a mango seedling inoculated with the anthracnose organism isolated from a mango leaf collected in Antipolo, Rizal Province; × 533.
3. A section through an acervulus from a 20-day-old potato-glucose-agar culture of the anthracnose organism isolated from mango flowers collected in Singalong, Manila. Note the development of fuscous black setæ; × 533.
4. Simple conidiophores shown as lateral outgrowths of the hyphæ. Obtained from a 1-month-old potato-glucose-agar culture of the anthracnose organism isolated from a mango stem collected in Cabagan, Isabela Province; × 533.
5. Spores from a 21-day-old potato-glucose-agar culture of the anthracnose organism isolated from the mango stem collected in Cabagan, Isabela Province; × 1200.
6. Conidiophores arising in groups from single hyphal cells. Obtained from 1-week-old culture of the anthracnose organism isolated from the mango stem collected in Cabagan, Isabela; × 1200. (All drawings in this plate were made with the aid of a camera lucida.)

PLATE 6

FIG. 1. A cracked fruit of the carabao variety. No organism is suspected of being responsible for the cracking; hence, it is regarded as a physiological trouble; × 2/3.

2. Mango shoots showing the infestation of tip borer. Note the shriveled and withered tips; × 1/3.
3. A leaf (right) from a mango seedling inoculated with the anthracnose organism isolated from mango flowers collected in Singalong, showing the symptoms of the disease; control leaf at the left; about × 2/3.

FIG. 4. Stems of mango seedlings inoculated with the anthracnose organism; *a*, inoculated with the organism from a mango leaf collected in Antipolo, Rizal Province; *b*, inoculated with the organism isolated from mango flowers collected in Singalong, Manila; *c*, inoculated with the organism isolated from a mango leaf collected in Muntinlupa, Rizal. All the inoculated seedlings showed numerous acervuli of the causal fungus on the stems; about × 2.

PLATE 7

FIG. 1. Showing a pico tree in blossom after the third weekly spraying with Bordeaux-nicotine-sulphate. The inflorescences which appeared healthy after the third spraying were severely damaged by the hoppers before the fourth weekly spraying was done; about × 1/60.

2. An inflorescence detached from the tree in fig. 1 showing no evident spray injury. Note the uniform coating of Bordeaux spray on the leaves; about × 1/3.

3. A hopper-infested inflorescence from a control tree showing growth of mold on the spikes and flowers. Note also that many of the flowers have dropped off; over × 1/3.

PLATE 8

FIG. 1. A carabao mango tree showing a fairly good yield after treating according to spray procedure given in Table 1 (see text). Note the fruits partially hidden under the leaves. The control part of the tree is not shown; about × 1/50.

2. A carabao mango tree treated according to the spray procedure in Table 2 (see text). Note the number of fruits that matured on the lower sprayed part of the crown. The upper, unsprayed portion shows relatively few fruits; about × 1/130.

PLATE 1.

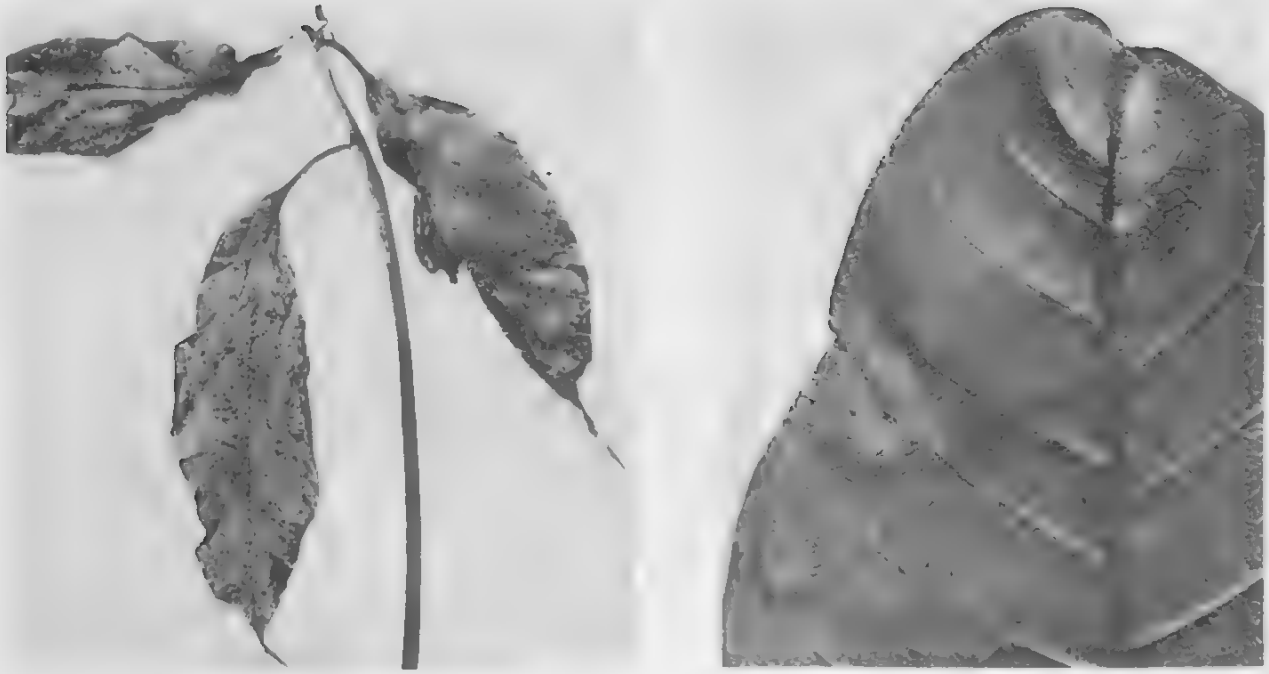

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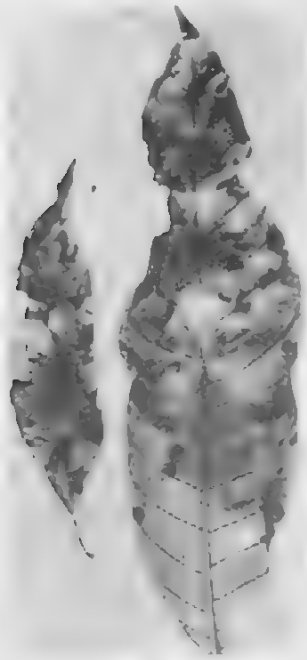
PLATE 2.



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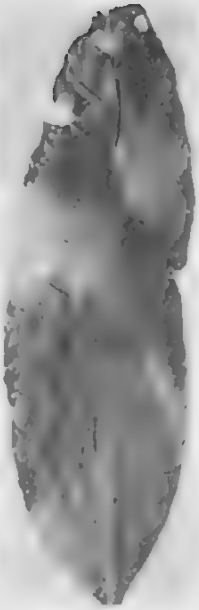

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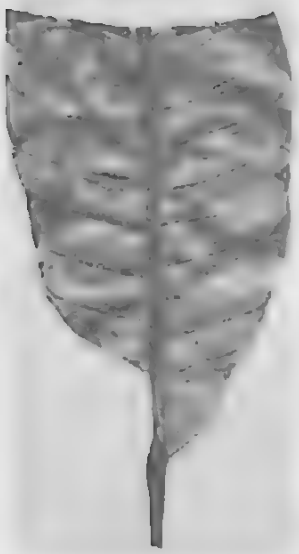

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PLATE 3.

PLATE 4.

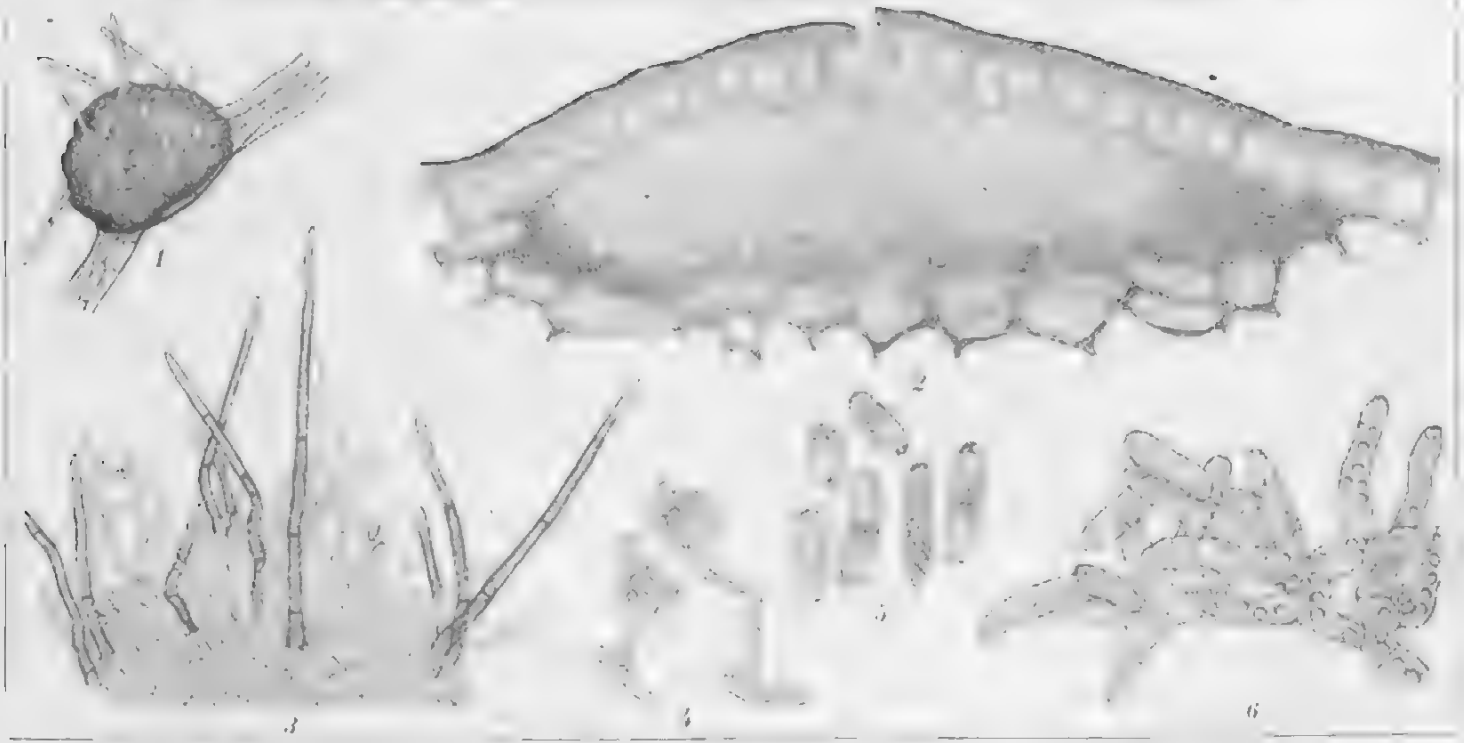

PLATE 5.

PLATE 6

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PLATE 7.

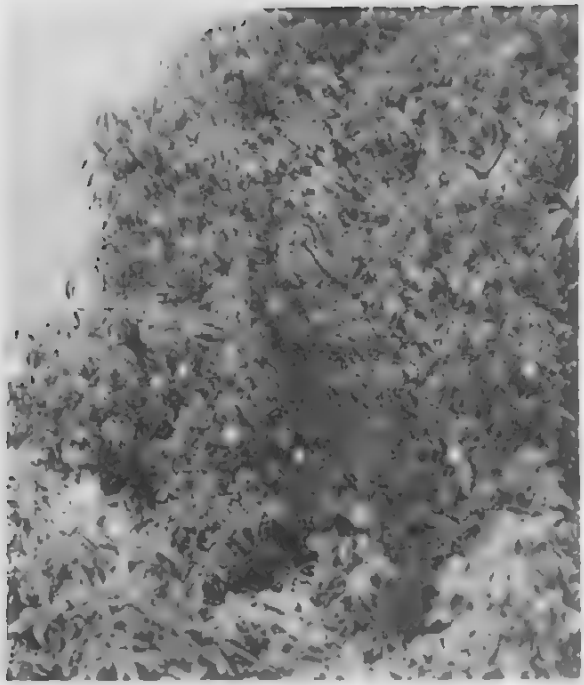

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PLATE 8.

THE INFLUENCE OF THE PERIOD OF AIR DRYING ON THE STRENGTH OF ABACÁ FIBER

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In the preparation of abacá fiber after its extraction from the leaf sheath it is the general practice to spread and allow it to dry for from eight to twelve hours or sometimes for very much longer periods, upon the apparent assumption that the period of drying is immaterial. As it was thought that this lack of uniformity in drying might result in a considerable variation in tensile strength of fibers from plants of the same variety growing in the same field or soil type, it was the aim of the present investigation to ascertain whether or not a difference in the drying period would make a difference in fiber strength and, incidentally, in fiber stretch.

The fibers of two of the commonest varieties of abacá found in Guinobatan, Albay Province, namely, the itom and puti tomatagakan, have been used in this study. These fibers came from flowering stalks grown in fields where the soils were of different types. They consisted of three separates from the outer, middle, and inner leaf sheaths, respectively. Each sample was divided into two portions, one of which was air-dried for ten hours and the other for twenty hours.

The method of determining tensile strength is described in detail in another paper.[1] The tensile strengths of fibers dried for 10- and 20-hour periods, respectively, together with their percentages of stretch and moisture contents are given in Table 1.

The tensile strength, according to the figures in columns 6, 9, and 12 of Table 1, seems to have been favorably affected by a longer period of air drying. Thus, column 6, which gives the average strength of not less than ten tests for each fiber separate from the outer leaf sheath, shows that in six cases out of eight the 20-hour dried portions were stronger by at least

[1] Philip. Journ. Sci. 48 (1932) 243.

TABLE 1.—*Moisture, amount of stretch, and tensile strength of abacá fibers from the outer, middle, and inner leaf sheaths.*

Variety.	Time dried.	Field.	Outer.			Middle.		
			Moisture (H_2O).	Average stretch in 20 cm.	Average tensile strength.	Moisture (H_2O).	Average stretch in 20 cm.	Average tensile strength.
	Hrs.		*P. ct.*	*P. ct.*	*Kg. per g.*	*P. ct.*	*P. ct.*	*Kg. per g.*
Itom	10	I	11.16	2.66	211.17	10.48	2.87	214.58
Do	10	II	10.30	3.27	235.82	10 29	3.54	254.07
Do	10	III	11 41	3.31	216.12	11.13	2.40	243 66
Do	10	IV	11.22	2.71	227.90	11.44	2 93	234.70
Do	20	I	10.82	2.94	255 21	10.27	2 78	257.75
Do	20	II	10.24	2.74	234 88	10.34	3.06	245 38
Do	20	III	11.02	2.79	255.17	10.35	3.04	251 76
Do	20	IV	11.08	2.98	282.43	10.73	2 94	245 78
Puti tomatagakan	10	I	10.82	2.99	240.70	11.23	3 35	266 63
Do	10	II	9.69	3.76	250.56	9.67	3.74	251 64
Do	10	III	12.67	2.29	200.72	9.93	2.75	216 06
Do	10	IV	10.90	3.14	222.83	11.15	2.90	214 09
Do	20	I	10.41	3.21	262.77	10.47	2.92	277 57
Do	20	II	10.37	3.27	247.70	10.19	3.04	268.68
Do	20	III	10.96	2.86	264.02	10.08	3.18	243.75
Do	20	IV	11.94	2.76	242.28	10.86	2.62	243 47

Variety.	Time dried.	Field.	Inner.			Tensile strength computed on the basis of moisture-free fiber.		
			Moisture (H_2O).	Average stretch in 20 cm.	Average tensile strength.	Outer.	Middle.	Inner.
	Hrs.		*P. ct.*	*P. ct.*	*Kg. per g.*	*Kg. per g.*	*Kg. per g.*	*Kg. per g.*
Itom	10	I	10.74	2.72	210.58	237.77	239.88	235 92
Do	10	II	10.47	3.11	203 61	262.93	283.03	238.15
Do	10	III	8.41	2.12	206.89	243.84	276.02	225.92
Do	10	IV	12.21	2.64	192.56	255.91	265.02	219.16
Do	20	I	10.54	2.59	211.28	285.95	287.24	236.02
Do	20	II	10.20	2.74	221.68	261.49	273.54	246.60
Do	20	III	10.11	2.77	229.40	286.53	290.77	254.89
Do	20	IV	10.97	2.82	236.37	317.08	276.06	265.27
Do	10	I	10.26	3.10	243.83	281.25	300.21	271.56
Puti tomatagakan	10	II	9.41	3.40	224.07	277.49	278.69	246.67
Do	10	III	10.15	2 57	225.38	229.82	239.86	250 84
Do	10	IV	10.90	2.98	231.93	250.19	240.83	259.80
Do	20	I	9.15	2.77	206.45	293.32	309.45	227.11
Do	20	II	10.00	2.72	213.87	276.26	299.11	237.23
Do	20	III	11.21	2.66	221.60	296.48	271.01	249.51
Do	20	IV	10.87	2.72	266.09	275.16	272.79	298.28

20 kilograms per gram than the 10-hour portions, and that in the other two cases the strength is practically the same for both portions if an allowance of ± 12 kilograms per gram be made, which allowance was actually found to be the maximum average variation in breaking strain for several sets of ten determinations performed for the same fiber portions. Columns 9 and 12, which correspond to the middle and inner leaf-sheath fibers, respectively, show similar increases, although in the case

TABLE 2.—*Gain or loss in tensile strength of abacá fiber incidental to its loss of moisture or to longer period of air drying.*

Variety.	Field.	Outer.				Middle.	
		Difference in moisture (H_2O) content between 10 and 20-hour dried fibers.	Observed loss or gain in strength incidental to longer period of drying.	Computed loss or gain in strength corresponding to change in moisture content.	Computed net loss or gain in strength.	Difference in moisture (H_2O) content between 10 and 20-hour dried fibers.	Observed loss or gain in strength incidental to longer period of drying.
		g.	*Kg. per g.*	*g.*	*Kg. per g.*	*g.*	*Kg. per g.*
Itom	I	0.0034—	48.18+	0.81+	47.37+	0.0021—	47.36+
Do	II	0.0006—	1.44—	0.16+	1.28—	0.0005+	9.49—
Do	III	0.0039—	42.69+	0.95+	41.74+	0.0078—	4.75+
Do	IV	0.0022—	61.17+	0.56+	60.61+	0.0071+	20.11+
Puti tomatagakan	I	0.0041—	12.07+	1.15+	11.92+	0.0076—	9.24+
Do	II	0.0068+	1.23+	1.89—	0.66+	0.0052+	20.42+
Do	III	0.0071—	66.66+	1.63+	65.03+	0.0015+	31.15+
Do	IV	0.0004+	24.97+	0.10—	25.07+	0.0029—	31.96+

Variety.	Field.	Middle.		Inner.			
		Computed loss or gain in strength corresponding to change in moisture content.	Computed net loss or gain in strength.	Difference in moisture (H_2O) content between 10 and 20-hour dried fibers.	Observed loss or gain in strength incidental to longer period of drying.	Computed loss or gain in strength corresponding to change in moisture content.	Computed net loss or gain in strength.
		g.	*Kg. per g.*	*g.*	*Kg. per g.*	*g.*	*Kg. per g.*
Itom	I	0.50+	46.86+	0.0020—	0.10+	0.47+	0.37—
Do	II	0.14—	9.35—	0.0027—	13.45+	0.63+	12.82+
Do	III	2.15+	2.60+	0.0070+	28.97+	1.58—	30.55+
Do	IV	1.88+	18.23+	0.0124—	46.11+	2.72+	43.39+
Puti tomatagakan	I	2.28+	6.96+	0.0011—	44.45—	0.30+	44.75—
Do	II	1.45—	21.87+	0.0059+	9.44—	1.46—	7.98—
Do	III	0.36—	31.51+	0.0106+	1.33—	2.66—	1.33+
Do	IV	0.70+	31.20+	0.0003—	38.48+	0.08+	38.40+

of the fibers from the inner section of the pseudostem of the puti variety the 20-hour dried portions have proved weaker than the 10-hour dried ones.

That the increase in strength noted for the 20-hour dried fibers could not be due to a decrease in moisture content and to a consequent increase in the weight or number of fiber strands that were subjected to stress seems to be demonstrated by the computed values in columns 13, 14, and 15 of Table 1, and particularly by the figures presented in Table 2, which were derived from the data contained in Table 1. The computed kilograms of force in columns 5, 9, 10, and 13 of Table 2 correspond to the differences in moisture content in grams (columns 3, 7, and 11) between the 10-hour and 20-hour dried fibers. If for these differences their equivalent weights of the fiber were substituted, variations would, as a rule, be extremely small or negligible as compared with the estimated net gains in strength per unit weight of the moisture-free fiber. For instance, in column 6 of Table 2 the net gains in strength vary from 11.92 to 65.03 kilograms per gram in six cases out of eight; in column 10, from 2.60 to 46.86 kilograms per gram in seven cases out of eight; and in column 14, from 1.33 to 43 kilograms per gram in five cases out of eight. If the maximum allowance for error of ±12 kilograms per gram were to be made, the result would be that out of twenty-four cases, fourteen would show computed net gains ranging from 0.8 to 54 kilograms per gram which may be attributed to longer drying; nine cases would show neither gain nor loss beyond the allowance for error, while in one case there was a loss. The increased strength incident to longer drying was most marked in the fibers from the outer section of the pseudostem, as these showed an average increase in strength of about 30 kilograms per gram; was less marked in the fibers from the middle part, which had an average increase in strength of 20 kilograms; and was still less marked or of doubtful significance in those from the inner part, where there was an average increase in strength of about 10 kilograms; three cases which came within the allowance of ± 12 kilograms, and the only case in which the fibers dried for twenty hours were weaker than those dried for ten hours by more than the allowance of ± 12 kilograms.

Adverting to the average percentages of stretch given in columns 5, 9, and 11 of Table 1, the results for the same fibers were so inconsistent as to convey the impression that the amount of stretch or elongation that the fibers could stand before break-

ing had not been influenced by the drying period or by the changes in moisture content which the fiber has undergone as a consequence of protracted air drying.

In connection with moisture change, it is of interest to note that from the figures in columns 4, 7, and 10 of Table 1, it appears that, under similar or the same weather conditions, fibers corresponding to the same leaf sheaths, air-dried for ten hours after their extraction, did not always seem to hold more moisture permanently than identical fibers dried for twenty hours, although ten additional hours of drying after the initial 10-hour period had in a great many cases caused a permanent moisture decrease in an amount seldom exceeding 1 per cent.

The foregoing results with regard to tensile strength afford an indication of the effect upon fiber strength of time length in air drying, and seem to suggest the advisability of taking this factor into account when determining the comparative strengths of abacá fibers.

Determination of the effect of sun drying on the strength of these fibers might prove an investigation of practical interest.

THE VARIABILITY OF TENSILE STRENGTH OF COMMERCIAL ABACÁ FIBERS OF THE SAME ORIGIN IN THE PSEUDOSTEM

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It has been observed that abacá fibers of the same origin in the pseudostem, dried for the same length of time, when tested for tensile strength by the use of a Louis Schöpper testing machine, according to the method described below, broke under diverse amounts of applied force which were out of all proportion to the differences in the quantity, by weight, of the fiber subjected to stress. The purpose of the present report is to invite attention to this fact and to show how the values for individual tests, expressed in kilograms of force per gram of the fiber, deviate from the mean of such values.

METHOD OF DETERMINING THE TENSILE STRENGTH OF ABACÁ

A portion of the fiber, nearly 40 centimeters long, which corresponds to the base or lower part of the leaf sheath is cut off the hank. Enough of the strands so cut are taken at random and arranged in such a way that the base end of a half of their number coincides with the opposite end of the other half. The extremities are then trimmed off by almost equal lengths so that a portion only about 27 centimeters long is left. This portion is clamped on a 50-kilogram Louis Schöpper testing machine. Both extremities of the portion are prevented from coming in direct contact with the metal clamps by wrapping them with blotting paper. Before the lower extremity is clamped on the machine the strands are properly arranged and straightened by a light pull, and are finally twisted so that all of them can, as much as possible, be subjected equally to stress. The speed of the shaft is 150 millimeters per minute. Upon completion of the test, the broken strands are clipped off as close as possible to the clamps and are made into a ball by squeezing and rolling them together between the dry thumb and forefinger. This ball is finally weighed in an analytical balance. In this

manner the actual tensile strength of a definite weight of the fiber sample is ascertained. Also, since the distance between clamps is 20 centimeters, a 40-centimeter portion of each strand is actually subjected to stress. For the capacity of the machine and with the ordinary abacá fiber, the actual weight of the fiber that can be tested at a time does not exceed 17 centigrams. For the sake of convenience and in order to acquire a clear idea of relative strengths the reading in kilograms corresponding to a definite weight or fraction of a gram is calculated to a common basis; namely, to kilograms per gram weight of the fiber.

In the following table are presented the data from a great number of tensile-strength tests of fibers taken from the five outer, five middle, and five or six inner leaf sheaths of the pseudostem of two varieties of abacá commonly grown in Guinobatan, Albay.

It is apparent from these tables that the breaking strains of equal quantities of fibers of the same origin in the same pseudostem vary through rather wide limits, and that the deviation of the value for any single test from that of the mean for a number of tests is considerable.

Regardless of variety this deviation is different for any set of tests, and for fibers from the outer and middle leaf sheaths its range is great, being 11.7 to 33.7 kilograms per gram in the present case. For fibers from the inner leaf sheaths this range seems to be still greater. It would seem, therefore, that great care should be exercised in judging the tensile strength of abacá, especially if only a few tests have been made.

TABLE 1.—*Tensile strength of dried fibers from various leaf sheaths of the pseudostem of two kinds of abacá.*

TENSILE STRENGTH OF 10-HOUR DRIED FIBERS FROM THE FIVE OUTER LEAF SHEATHS OF THE PSEUDOSTEM OF ITOM.

Trial No.—	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.
	FIELD I, FIBER GRADE S1.				FIELD II, FIBER GRADE S1.				FIELD III, FIBER GRADE S1.				FIELD IV, FIBER GRADE S1.			
	g.	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*
1	0.1470	29.10	198.0	2.80	0.1456	26.10	179.4	3.00	0.1450	36.65	252.7	3.20	0.1440	32 30	224.3	3.00
2	0.1480	31.00	209.5	2.80	0.1440	35.00	243.0	3.40	0.1555	32.60	209.6	3.30	0.1460	37.80	258.9	2.80
3	0.1480	34.60	233.8	3.00	0.1400	30 00	214.3	3.00	0.1455	34.05	234.0	3.40	0.1430	28.90	202.1	2.40
4	0.1410	32.70	231.9	2.80	0 1440	36 50	253.5	3.00	0.1490	32.00	214.7	3.40	0.1405	34 00	242.0	3.00
5	0.1410	30.80	218.4	2.40	0.1465	31.50	215.0	3 40	0.1535	34.60	225.0	3.70	0.1430	32.30	225.9	3.00
6	0.1470	32.70	222.4	2.60	0.1465	33.50	228.7	3.40	0.1520	23.85	189.8	3 00	0.1415	31.90	225.4	2.40
7	0.1420	25.90	182 4	2.40	0.1455	36.40	250.3	3.40	0.1490	29.90	200.6	3.50	0.1435	34.70	241.8	2.60
8	0.1430	30.20	211.2	2.60	0.1455	40.50	278.4	3.00	0.1505	37.45	248.8	3.33	0.1430	34.60	233.8	3.00
9	0.1440	33.10	229.9	2.60	0.1420	33.80	238.1	3.40	0.1570	32.50	207.0	3.20	0.1430	30.40	212.6	2.40
10	0.1440	31.80	220.8	2.60	0.1420	30.00	211.3	3.00	0.1465	26.30	179.0	3.10	0.1450	29.20	201.4	2.80
11	0.1435	26.60	185.4	2.60	0.1440	36.00	250.0	3.60	------	------	------	------	0.1510	32.70	216.6	2.80
12	0.1450	27.60	190.3	2.80	0.1480	42.50	287.2	3.40	------	------	------	------	0.1435	36.00	250.9	2.40
13	------	------	------	------	0.1440	34.50	239.6	3.40	------	------	------	------	------	------	------	------
14	------	------	------	------	0.1455	30.80	211.7	3.40	------	------	------	------	------	------	------	------
Mean	------	------	211.17	2.66	------	------	235 82	3 27	------	------	216.12	3.31	------	------	227.90	2.71
Standard deviation of single tests from the mean	------	------	±17.5	------	------	------	±27.5	------	------	------	±22.9	------	------	------	±17.5	------

TABLE 1.—*Tensile strength of dried fibers from various leaf sheaths of the pseudostem of two kinds of abacá*—Continued.

TENSILE STRENGTH OF 10-HOUR DRIED FIBERS FROM THE FIVE OUTER LEAF SHEATHS OF THE PSEUDOSTEM OF PUTI TOMATAGAKAN.

Trial No.—	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.
	FIELD I, FIBER GRADE S_1 AND S_2.				FIELD II, FIBER GRADE F.				FIELD III, FIBER GRADE S_1.				FIELD IV, FIBER GRADE S_2.			
	g.	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*
1	0.1380	34.00	246.4	2.80	0.1510	43 40	287.4	3.80	0.1450	27.60	190 3	1.90	0.1460	33.50	229 6	3.00
2	0.1395	32.50	233.0	3.40	0 1465	33 90	231.4	3.60	0.1450	27.60	190.3	1.90	0.1500	34.50	230.0	3 20
3	0.1425	37.60	263.9	3.20	0.1485	43.40	292.5	4.20	0.1460	26.50	181.5	2.00	0.1500	29.00	193.3	3 20
4	0.1415	30.60	216.3	2.80	0.1510	38.50	255.0	3.80	0.1375	32.20	234.1	1.90	0.1410	30.40	215.6	3 60
5	0.1440	31.00	215.3	3 00	0.1510	41.10	272.2	3.40	0.1490	31.10	208.7	2 00	0.1400	25.00	178.6	3 00
6	0.1440	38.50	267.4	3.00	0.1535	40.50	263.8	3.40	0.1470	29 00	197.3	2.20	0 1390	34 30	246.9	3.00
7	0.1435	37.10	258.5	2.80	0.1470	31.60	215.0	4.20	0.1400	28.30	202.0	2.00	0.1480	37 60	254.1	2.90
8	0.1405	31.00	220.6	2.80	0.1500	36.80	245.3	4.20	0.1400	27.40	195.7	2.40	0.1360	30 30	222.8	3 50
9	0.1445	37.00	256.1	3.00	0.1465	32.10	220.0	3 80	0.1400	26.60	190.0	2.20	0.1460	35 50	243.2	3 00
10	0.1410	36.60	259.6	3.00	0.1480	41.30	279.0	3.60	0.1420	31.00	217.3	2 00	0.1410	30 20	214 2	3.00
11	0.1445	40.20	278.1	3.00	0.1475	36.90	251.0	3.80								
12	0.1425	29.00	203.5	2.80	0.1485	29.90	201.3	3.60								
13	0 1430	32 00	223.8	2.80	0.1510	39.10	258.9	3.40								
14	0.1425	31 90	223.9	3.00	0.1450	31.30	215.9	3.80								
15	0 1480	38.60	260.8	3.00	0.1490	40.10	270.0	3.80								
16	0.1435	32.20	224.3	3.40												
Mean			240.70	2.99			250.56	3.76			200.72	2 29			222.83	3.14
Standard deviation of single tests from the mean			±22.5				±27.4				±14.8				±22 4	

TENSILE STRENGTH OF 20-HOUR DRIED FIBERS FROM THE FIVE OUTER LEAF SHEATHS OF THE PSEUDOSTEM OF ITOM.

	FIELD I, FIBER GRADE S_3.				FIELD II, FIBER GRADE S_3.				FIELD III, FIBER GRADE S_3.				FIELD IV, FIBER GRADE S_3.			
1	0.1415	34.80	245.9	2.80	0.1455	26.80	184.2	2.60	0.1480	36.60	247.4	2.80	0.1450	44.60	307.6	3.20
2	0.1440	33.00	229.2	2.80	0.1430	35.00	244.8	2.80	0.1440	37.30	259.0	3.00	0.1480	41.60	282.0	3.20
3	0.1415	36.80	260.7	2.80	0.1430	36.30	253.1	3.40	0.1430	32.10	224.5	2.30	0.1460	38.20	261.6	3.00
4	0.1465	32.10	219.1	2.80	0.1465	27.80	189.8	2.60	0.1450	38.50	265.5	2.80	0.1450	39.10	269.7	2.80
5	0.1415	36.30	256.5	3.00	0.1465	30.40	207.5	2.60	0.1365	37.60	275.5	3.00	0.1425	41.50	291.0	3.00
6	0.1460	36.60	250.7	3.00	0.1430	38.10	266.4	3.20	0.1482	36.50	245.6	2.80	0.1460	37.60	257.5	2.60
7	0.1400	38.80	277.1	3.00	0.1433	38.20	266.6	3 20	0.1495	40.20	268.9	2.80	0.1470	42.50	290.0	2.80
8	0.1400	34.80	248.6	3.00	0.1435	35.20	245.3	2.80	0.1490	36.40	244.6	2.80	0.1385	38.40	277.3	2.60
9	0.1420	39.80	280.3	3.00	0.1415	31.90	225.4	3.00	0.1460	36.80	252.1	2.80	0.1470	41.60	283.0	2.60
10	0.1440	40.90	284.0	3.20	0.1415	37.60	265.7	3.20	0.1400	37.50	267.9	2.80	0.1415	43.10	304.6	3.00
Mean			255 21	2.94			234.88	2.74			255 17	2 79			282.43	2.98
Standard deviation of single tests from the mean			±20 2				±29.9				±17.6				±15.8	

TABLE 1.—*Tensile strength of dried fibers from various leaf sheaths of the pseudostem of two kinds of abacá*—Continued.

TENSILE STRENGTH OF 20-HOUR DRIED FIBERS FROM THE FIVE OUTER LEAF SHEATHS OF THE PSEUDOSTEM OF PUTI TOMATAGAKAN.

Trial No.—	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.
	FIELD I, FIBER GRADE S_1 AND S_2.				FIELD II, FIBER GRADE F.				FIELD III, FIBER GRADE S_2.				FIELD IV, FIBER GRADE S_1.			
	g.	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*
1	0.1410	28.50	202.1	2.80	0.1395	38.10	273.1	3 20	0.1510	31.80	210.6	3.00	0.1410	32.30	230.0	2.80
2	0.1440	35.60	247.2	3 40	0.1470	35.20	239.5	3 20	0.1490	40.90	274.5	3.00	0 1470	35.20	239.5	3.00
3	0.1430	41.60	290.9	3.20	0.1440	34.30	238.2	3.21	0.1550	36.60	236 0	2.80	0.1470	41.00	278.9	2.80
4	0.1410	42 60	302.1	3.20	0.1445	36.60	253.3	3.40	0.1485	40 40	272.0	2 80	0.1475	40.60	275.3	3.00
5	0.1445	37.30	258.1	3.00	0.1465	37.40	255.3	3.50	0.1500	37 60	250 7	2.80	0.1470	37.80	258.0	3.00
6	0.1420	38 60	271.8	3.60	0.1405	35.00	249.1	3.50	0.1460	45 70	313 0	3 00	0.1475	33.30	225.8	2.60
7	0.1445	41.00	283.7	3.50	0.1430	36.50	255 2	3 20	0 1490	39 10	262.4	2.80	0.1440	36.00	250.0	2.80
8	0 1420	28.00	197.2	3.00	0.1430	34.60	242.0	3 20	0 1480	39.40	264 4	3 00	0 1405	32.30	230.0	2.60
9	0.1410	44.30	314.2	3 60	0.1450	36 20	249 7	3 30	0 1456	40 20	274 0	2 60	0.1450	29.80	205.5	2.40
10	0 1440	37.50	260 4	2.80	0 1435	31.80	221 6	3.20	0.1550	43.50	280.6	2.80	0.1375	31.60	229.8	2.60
Mean			262.77	3 21			247.70	3 27			264 02	2.86			242.28	2.76
Standard deviation of single tests from the mean			±33.7				±12 9				±26.0				±21.9	

TENSILE STRENGTH OF 10-HOUR DRIED FIBERS FROM THE FIVE MIDDLE LEAF SHEATHS OF THE PSEUDOSTEM OF ITOM.

	FIELD I, FIBER GRADE E.				FIELD II, FIBER GRADE D.				FIELD III, FIBER GRADE E				FIELD IV, FIBER GRADE D AND E.			
1	0.1410	28.40	197.2	2.60	0.1400	28.00	200.0	3.00	0.1410	37.30	264.5	2.40	0.1390	27.10	195.0	2.40
2	0.1440	26.20	181.9	2.60	0.1435	40.00	278.7	3.40	0.1400	41.40	295.7	2.60	0.1470	36.80	250.3	3.00
3	0.1410	34.10	241.8	3.00	0.1470	31.00	210.9	3.00	0.1475	33.60	227.8	3 00	0.1450	39.40	271.7	3.00
4	0.1455	33.50	230.2	3.00	0 1440	33.00	229.2	4.00	0.1475	40.40	273.9	2.40	0.1430	29.00	202.8	3.00
5	0.1480	31.80	214.9	2.80	0.1445	32.00	221.5	3.60	0.1450	32.60	224.8	2.30	0.1505	31.20	207.3	2.60
6	0.1420	35 20	247.8	2.80	0.1420	36.50	257.0	3.80	0.1460	36.15	247.2	2.80	0.1490	35.80	240.3	2.60
7	0.1440	35 00	243.0	3.00	0.1480	30.40	205.4	3.80	0.1470	32.45	220.4	2.20	0.1460	38.90	266.4	3.00
8	0.1460	29.50	202.0	3.00	0.1450	37.20	256.5	3.40	0.1490	39.00	261.7	3.40	0.1445	30.80	213.1	3.00
9	0.1440	28.70	199.3	2.80	0.1470	38.10	259.2	3.60	0.1450	35.80	243.4	2.40	0.1380	36.70	265.9	3.00
10	0.1470	33.60	227.9	3.40	0.1450	45 20	312.7	3.60	0.1490	33.60	225.5	2.20	0.1470	33.00	224.5	3.00
11	0.1435	29.10	202.8	2.80	0.1425	39 60	277.9	3.40	0.1510	40.15	265.9	2.40	0.1480	34.80	235.1	3.00
12	0.1370	25.50	186.1	2.60	0.1440	43.10	299.3	4.00	0.1455	37.45	257.4	2.30	0.1420	32.10	226.0	2.80
13					0.1415	34.40	243.1	3.60	0.1465	37.00	254.3	2.50	0.1400	33.50	239.8	3 20
14					0.1420	43.40	305.6	3 20	0.1465	34.30	234.1	2 00	0.1410	35.00	248 2	3.40
15									0.1450	39 00	269 0	2 20				
16									0.1410	33.20	235.5	2 20				
17									0.1450	33.05	227.9	2 20				
18									0.1495	32.00	214.7	2 20				
19									0.1510	35.80	237.1	2 20				
20									0.1510	35.10	232.5	2 20				
Mean			214.58	2.87			254.07	3.54			245.66	2.40			234.70	2.93
Standard deviation of single tests from the mean			±22.0				±34.4				±21.8				±23.6	

TABLE 1.—*Tensile strength of dried fibers from various leaf sheaths of the pseudostem of two kinds of abacá*—Continued.

TENSILE STRENGTH OF 10-HOUR DRIED FIBERS FROM THE FIVE MIDDLE LEAF SHEATHS OF THE PSEUDOSTEM OF PUTI TOMATAGAKAN.

Trial No.—	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per grom.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.
	FIELD I, FIBER GRADE D AND E.				FIELD II, FIBER GRADE E.				FIELDI II, FIBER GRADE E.				FIELD IV, FIBER GRADE E.			
	g.	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*
1	0.1420	38.00	265.7	3.40	0.1400	40.50	289.4	4.00	0.1465	27.20	185.7	2.40	0.1510	35.00	231.9	3.00
2	0.1425	36.70	257.5	2.80	0.1450	38.80	267.6	4.00	0.1480	31.80	214.8	2.60	0.1445	34.90	241.6	3.00
3	0.1395	44.80	321.2	3.40	0 1450	39.90	275.2	4 20	0.1430	27.00	188.8	2.40	0.1420	25.40	178.9	2.60
4	0.1450	41 20	284.1	3.00	0.1465	38.20	260.8	3.60	0.1405	27.50	195.7	2.60	0.1465	26.50	180.9	2.60
5	0.1420	39.70	279.5	3.60	0.1470	36.40	247.6	3.80	0.1400	31.50	225.0	2.40	0.1390	35.00	251.8	3.00
6	0.1475	35.80	242.7	3.00	0.1430	30.00	209.8	3.40	0.1470	37.20	253.1	3.00	0.1440	29.80	206.9	3.00
7	0.1415	34.70	245.2	4.00	0.1450	37.60	259.3	3.40	0.1395	28.00	200.7	3.00	0.1490	32.00	214.8	2.80
8	0.1470	37.00	251.7	3.00	0.1390	33.10	238.1	3.80	0.1450	36.00	248.3	3.00	0.1440	35.10	243.8	3 00
9	0.1450	35.10	242.0	3.60	0.1430	35.40	247.6	3.40	0.1470	32.90	223.8	2.40	0.1460	30.00	205.5	2.80
10	0.1440	43.00	298.6	3.60	0.1460	34.80	238.4	3.80	0.1470	35.20	239.5	3.40	0.1420	30.40	214.1	3.00
11	0.1440	40.00	277.8	3.60	0.1430	35.20	246.1	3.80	0.1440	32.50	225.7	3.40	0.1440	29.80	206 9	2.80
12	0.1475	38.00	257.6	3.40	0.1450	35.80	246.9	3.40	0.1485	28 20	189.9	2.40	0.1490	28.20	189.3	3 00
13	0.1440	38.70	268.8	3.40	0.1450	34.80	240.0	3.60	------	------	------	------	0.1390	32.00	230.2	3.00
14	0.1440	35.70	247.9	3.00	0.1430	38.40	268.5	4.00	------	------	------	------	0.1420	28.50	200.7	3.00
15	0.1470	38.10	259.2	3.40	0.1455	38.80	266.7	3.80	------	------	------	------	------	------	------	------
16	------	------	------	------	0.1405	31.50	224.2	3.80	------	------	------	------	------	------	------	------
Mean	------	------	266.63	3.35	------	------	251.64	3.74	------	------	216.06	2.75	------	------	214.09	2.90
Standard deviation of single tests from the mean	------	------	±22.2	------	------	------	±19.3	------	------	------	±22.7	------	------	------	±22.3	------

TENSILE STRENGTH OF 20-HOUR DRIED FIBERS FROM THE FIVE MIDDLE LEAF SHEATHS OF THE PSEUDOSTEM OF ITOM.

	FIELD I, FIBER GRADE E.				FIELD II, FIBER GRADE D.				FIELD III, FIBER GRADE E.				FIELD IV, FIBER GRADE D AND E.			
1	0.1440	40.00	277.8	2.80	0.1430	29.80	208.4	3.20	0.1450	35.00	241.4	3.20	0.1480	32.50	219.6	3.00
2	0.1370	32.10	234.3	2.60	0.1427	33.40	234.0	3.20	0.1435	35.20	245.3	3 00	0.1485	30.20	203.4	2 60
3	0.1420	43.60	307.0	2.80	0.1385	36.00	260.4	3.20	0.1475	36 80	249.5	2.80	0.1425	40.50	284.2	3.40
4	0.1440	40.60	281.9	3.00	0.1430	37.10	259.4	3.20	0.1450	33.10	228.3	3.00	0.1450	35.60	245.5	2.80
5	0.1470	37.10	252.4	3.00	0.1440	34 60	240.2	2.80	0.1435	36.00	250.9	3.00	0.1455	37.80	259.8	3.20
6	0.1455	34 60	237.8	2.80	0.1420	32.90	231.7	2.80	0.1450	31.20	215.2	3.20	0.1455	34.20	235.1	2.60
7	0.1480	36.10	243.9	2.80	0.1420	33.40	235.2	3.00	0.1440	38.10	264.6	3.00	0.1435	40.90	284.9	3 20
8	0.1450	37 30	257.2	2.80	0.1450	40.00	275.9	3.40	0.1480	39.60	267.6	3.00	0.1445	30.60	211.8	2 60
9	0.1425	34 50	242.1	2.60	0.1425	40.80	286.3	3.20	0.1420	39.80	280.3	3.00	0.1455	39.80	273.5	3.20
10	0.1440	35.00	243.1	2.60	0.1480	32.90	222.3	2.60	0.1450	39.80	274.5	3.20	0.1450	34.80	240.0	2.80
Mean			257.75	2.78			245.38	3.06			251.76	3.04			245.78	2 94
Standard deviation of single tests from the mean			±22.4				±23.2				±19.5				±27.8	

TABLE 1.—*Tensile strength of dried fibers from various leaf sheaths of the pseudostem of two kinds of abacá*—Continued.

TENSILE STRENGTH OF 20-HOUR DRIED FIBERS FROM THE FIVE MIDDLE LEAF SHEATHS OF THE PSEUDOSTEM OF PUTI TOMATAGAKAN.

Trial No.—	Field I, fiber grade D and E.				Field II, fiber grade E.				Field III, fiber grade E.				Field IV, fiber grade E.			
	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.
	g.	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*
1	0.1440	37.50	260.4	3.00	0.1445	39.90	276.1	3.40	0.1480	39.70	268.2	3.20	0.1440	25.00	173.6	2.20
2	0.1425	42.10	295.4	3.40	0.1445	39.60	274.0	3.40	0.1515	35.30	233.0	3.20	0.1425	31.60	222.5	2.40
3	0.1490	38.80	260.4	3.00	0.1445	39.20	271.3	2.90	0.1473	37.50	254.6	3.40	0.1387	40.60	292.7	3.20
4	0.1455	42.00	288.7	3.00	0.1415	38.90	274.9	3.00	0.1520	37.50	246.7	3.60	0.1460	36.00	246.6	2.80
5	0.1420	44.40	312.6	3.20	0.1400	35.50	253.6	3.00	0.1450	34.00	234.5	3.00	0.1425	36.60	256.8	2.40
6	0.1430	42.70	298.6	3.00	0.1375	34.80	253.1	2.80	0.1535	39.50	257.3	3.20	0.1425	40.90	287.0	2.80
7	0.1480	42.80	289.1	3.00	0.1395	39.80	285.3	3.20	0.1510	34.40	227.8	3.20	0.1430	37.40	261.5	2.60
8	0.1430	35.80	250.3	2.60	0.1345	38.20	284.0	3.20	0.1530	37.90	247.7	3.00	0.1440	31.30	217.4	2.60
9	0.1465	38.20	260.8	3.00	0.1448	37.30	257.6	3.20	0.1530	33.20	217.0	3.00	0.1440	37.40	259.7	2.60
10	0.1430	37.10	259.4	3.00	0.1440	37.00	256.9	3.00	0.1480	37.10	250.7	3.00	0.1420	31.30	220.4	2.40
11													0.1380	33.00	240.0	2.80
Mean			277.57	2.92			268.68	3.04			243.75	3.18			243.47	2.62
Standard deviation of single tests from the mean			±20.4				±11.7				±14.7				±32.5	

TENSILE STRENGTH OF 10-HOUR DRIED FIBERS FROM FIVE OR SIX INNER LEAF SHEATHS OF THE PSEUDOSTEM OF ITOM.

	FIELD I, FIBER GRADE E.				FIELD II, FIBER GRADE C.				FIELD III, FIBER GRADE C.				FIELD IV, FIBER GRADE D.			
1	0.1425	32.50	228.1	2.40	0.1460	24.80	169.9	3.00	0.1400	27.00	192.9	2.00	0.1490	29.70	199.3	2.60
2	0.1410	30.30	214.9	3.00	0.1475	34.80	235.9	3.20	0.1420	30.20	212.7	2.00	0.1470	26.10	177.6	2.40
3	0.1410	30.20	214.2	2.80	0.1435	34.10	237.6	3.20	0.1380	31.80	230.4	2.10	0.1460	31.50	215.8	3.00
4	0.1450	30.80	212.4	3.00	0.1445	29.40	203.5	3.00	0.1410	24.40	173.0	2.00	0.1440	27.20	188.9	2.80
5	0.1400	26.00	190.0	2.80	0.1490	30.30	203.4	3.00	0.1450	32.40	223.4	2.20	0.1490	23.80	159.7	2.60
6	0.1425	26.20	183.8	2.60	0.1425	34.40	241.4	3.20	0.1455	34.80	239.1	2.30	0.1455	26.80	184.2	2.40
7	0.1425	32.00	224.6	2.80	0.1520	38.20	251.3	3.80	0.1480	28.90	195.3	2.30	0.1480	26.60	179.7	2.40
8	0.1420	24.70	173.9	2.40	0.1460	24.30	164.2	3.00	0.1455	30.70	213.9	2.00	0.1400	29.80	212.9	2.60
9	0.1440	34.20	237.5	2.80	0.1480	27.40	185.0	3.20	0.1445	24.40	169.0	1.90	0.1470	30.00	204.1	2.80
10	0.1440	30.50	211.8	2.80	0.1450	30.40	209.7	3.20	0.1435	31.50	215.5	2.20	0.1460	29.70	203.4	2.80
11	0.1385	33.30	240.4	2.60	0.1434	31.80	221.8	3.20								
12	0.1410	32.00	227.0	2.80	0.1480	26.60	179.7	3.40								
13	0.1445	27.00	186.9	2.60												
14	0.1425	27.00	189.5	2.80												
15	0.1455	32.50	223.4	2.60												
Mean			210.56	2.72			208.61	3.11			206.89	2.12			192.56	2.64
Standard deviation of single tests from the mean			± 6.4				±28.2				±22.2				±16 7	

TABLE 1.—*Tensile strength of dried fibers from various leaf sheaths of the pseudostem of two kinds of abacá*—Continued.

TENSILE STRENGTH OF 10-HOUR DRIED FIBERS FROM FIVE OR SIX INNER LEAF SHEATHS OF THE PSEUDOSTEM OF PUTI TOMATAGAKAN.

Trial No.—	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.
	FIELD I, FIBER GRADE D AND E.				FIELD II, FIBER GRADE D.				FIELD III, FIBER GRADE E.				FIELD IV, FIBER GRADE D.			
	g.	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*
1	0.1460	35.50	243.2	3 80	0.1510	32.90	217.9	3.40	0.1400	30.20	215.7	3.40	0.1470	33.40	227.2	3 00
2	0.1460	34.50	236.3	3.40	0.1545	32.50	210.4	3.40	0.1355	31.50	232.5	2.30	0.1455	41.50	285.2	3.00
3	0.1450	35 00	241.4	3.00	0.1485	36.70	247.1	3.60	0.1410	28.00	198.5	2.40	0.1440	34.40	238.9	3 00
4	0.1450	32.50	218.1	2 80	0.1520	33.30	219.1	3.60	0.1410	32.50	230.5	2.50	0.1455	27 00	185.6	3.00
5	0.1440	41.50	288.2	3.00	0.1430	34.00	237.8	3.60	0.1480	29.10	196.6	2.40	0.1470	29.00	197.3	3.00
6	0.1450	38.90	268.3	3.00	0.1510	33.30	220.5	3.20	0.1385	37.30	269 3	2.70	0.1450	31.50	217.2	3.20
7	0.1450	30.50	210.3	2.80	0.1685	37.20	220.8	3.60	0.1450	30.40	209.7	2.90	0.1455	31.60	217.2	3.20
8	0.1460	37.00	253.4	2.80	0.1740	28 70	164 9	2.40	0.1460	31.80	217.8	2.30	0.1435	42.00	292.6	3.20
9	0.1470	30.20	205.4	2.40	0.1535	35 80	233.2	3.40	0.1460	33.30	228.0	2.60	0.1435	37.50	261.3	3.00
10	0.1450	40 00	275.9	3.20	0.1695	39.10	230.7	3 60	0.1480	37.70	254.7	2.40	0.1450	27.50	189.6	2 60
11	0.1430	30.90	216.1	3.00	0.1475	34.60	234.5	3 60	0.1440	34.20	237.5	2.40	0.1490	33.10	222.2	2 60
12	0.1420	38.30	269.7	3.00	0.1625	37.70	232.0	3.40	0.1410	30.30	214.8	2.60	0.1430	35 60	248.9	3 00
13					0.1490	34.90	234.2	3.40								
14					0.1420	33 30	234.5	3.40								
Mean			243.83	3 01			224.07	3.40			225.38	2.57			231.93	2.98
Standard deviation of single tests from the mean			±26.8				±18.9				±21.0				±33.4	

TENSILE STRENGTH OF 20-HOUR DRIED FIBERS FROM FIVE OR SIX INNER LEAF SHEATHS OF THE PSEUDOSTEM OF ITOM.

	FIELD I, FIBER GRADE E.				FIELD II, FIBER GRADE C.				FIELD III, FIBER GRADE C.				FIELD IV, FIBER GRADE D.			
1	0.1410	36.70	260.2	2.60	0.1390	28.50	205.8	2.60	0.1485	36.40	245.1	3 00	0.1440	36.60	254 2	3.00
2	0.1480	29 10	196.6	2.50	0.1417	34.00	240.7	3.00	0.1460	28.90	197.9	2 40	0.1470	37.10	252.4	2.80
3	0.1450	29 20	200.1	2.60	0.1385	34.30	247.7	3.00	0.1430	35 90	251.1	3 00	0.1460	38 90	266.4	3.00
4	0.1435	38.10	265.5	2.60	0.1410	35.10	248.2	3.00	0.1460	37 40	256.2	3.00	0.1490	23.90	160.4	2.40
5	0.1470	27.50	187.0	2.40	0.1420	28.50	200.7	2.60	0.1495	28.40	190.0	2.40	0.1485	34.10	229.6	2.80
6	0.1435	24.10	167.8	2.80	0.1430	30.00	209.8	2.60	0.1425	36.00	252.6	3.00	0.1420	36.00	257.7	3.00
7	0.1425	37.30	261.7	2.40	0.1460	30.20	206.8	2.60	0.1435	33.90	236.2	3.20	0.1475	34.00	230.5	2.60
8	0.1450	23.30	160.7	2.40	0.1445	34.40	238.1	2.80	0.1480	30.20	204.1	2.40	0.1475	29.50	200.0	2.80
9	0.1490	33.80	226.8	2.40	0.1430	27.70	193.7	2.40	0.1480	34.20	231.4	2.50	0.1475	35.20	238.7	2.80
10	0.1470	27.40	186.4	2.80	0.1460	32.90	225.3	2.80					0.1435	39.30	273.8	3.00
Mean			211.28	2.59			221.68	2.74			229.40	2.77			236.37	2.82
Standard deviation of single tests from the mean			±37.5				±25.1				±24.1				±32.4	

TABLE 1.—*Tensile strength of dried fibers from various leaf sheaths of the pseudostem of two kinds of abacá*—Continued.

TENSILE STRENGTH OF 20-HOUR DRIED FIBERS FROM FIVE OR SIX INNER LEAF SHEATHS OF THE PSEUDOSTEM OF PUTI TOMATAGAKAN.

Trial No.—	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.	Weight of strand 20 cm long.	Tensile strength.	Computed tensile strength per gram.	Stretch in 20 cm.
	FIELD I, FIBER GRADE D AND E.				FIELD II, FIBER GRADE D.				FIELD III, FIBER GRADE E.				FIELD IV, FIBER GRADE D.			
	g.	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*	*g.*	*kg.*	*kg.*	*P. ct.*
1	0.1440	22.40	155.6	2.60	0.1465	27.00	184.3	2.60	0.1470	27.70	188.6	2.40	0.1440	39.60	275 0	2.60
2	0.1425	30.80	216.1	3.00	0.1440	2.70	157.6	2.40	0.1500	37.00	246.7	2.80	0.1440	36.60	254 2	2.60
3	0.1435	23.00	160.3	2.60	0.1410	34.00	241.1	3.00	0.1445	33.00	233 2	2.60	0.1440	40.00	277 8	2 80
4	0.1410	34.00	241.1	2.80	0.1420	28.30	199.3	2.80	0.1470	37.50	255.1	3.00	0.1475	43.60	295 6	2 80
5	0.1500	24.30	162.0	2.40	0.1425	35.80	251.2	3.40	0.1480	28.90	195.3	2.60	0.1470	38.00	258 5	2 80
6	0 1445	37.40	259.8	3.00	0.1430	33.40	233.6	3 40	0.1530	33 10	216 3	2.60	0.1485	32.30	217 5	2.60
7	0.1445	35.60	246 4	3.30	0.1415	36.50	257.9	3 20	0.1450	31.50	217.2	2 60	0.1430	37.40	261.5	2.60
8	0.1440	37.90	263.2	3 00	0.1480	34 80	167.6	2.60	0 1480	29.30	198 0	2 60	0 1455	40 20	276.3	2.80
9	0.1410	21.80	154.6	2.20	0.1430	33 00	230.8	3 00	0 1460	36.70	251 4	2 80	0 1410	38 00	269 5	2.80
10					0.1440	21 00	215 3	2.80	0.1480	31.70	214 2	2.60	0.1440	39 50	275 0	2 80
Mean			206 45	2.77			213.87	2.72			221 60	2 66			266.09	2.72
Standard deviation of single tests from the mean			±45.0				±33 2				±24 9				±19 6	

TWO CONVENIENCES FOR PHYTOPATHOLOGICAL WORK IN THE TROPICS

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TWO PLATES

Soon after the writer assumed charge of investigations in plant pathology and mycology at the Bureau of Science, Manila, a need was felt for suitable apparatus for the preparation of pure cultures and for the propagation from seed of plants needed for artificial infection, as a result of which past experience was drawn upon and certain modifications made in existing appliances. As these are well adapted to our work, and may prove useful to others, they are perhaps worth recording. There is nothing new, however, in the general idea of making cultures in a closed chamber or of keeping plants under cover to maintain them free of undesirable pathogenes. What the writer wishes to point out are only certain improvements or adaptations of well-known apparatus, particularly for tropical work.

A SERVICEABLE CULTURE CASE

While in charge of timber-decay investigations at the United States Forest Products Laboratory, Madison, Wisconsin, the writer had occasion to construct several culture cases for the isolation and transfer of various organisms concerned in the deterioration of wood or wood products. Some of these cases gave considerable trouble from the swelling and subsequent shrinkage of the wood, which ultimately produced cracks at the joints, thus rendering the cases unsuitable for careful work.

A type of construction was finally developed in which the wood did not "work" undesirably. The principal source of trouble in an ordinary case lies in the bottom, which swells excessively from the application of mercuric chloride solution, or other sterilizing agents prepared with water. To overcome this a lead sheet at least ⅛-inch thick was closely fitted over the bottom, with the edge set with white lead into an upward slanting groove in the side walls of the case, about an inch from the bottom. This caused all drainage from the walls and top to

collect on the lead surface of the bottom, thus maintaining the floor boards in a dry condition and obviating all swelling and shrinkage, with its consequent pushing outward of the walls of the case. Lead was used because it is highly resistant to mercury salts.

In the construction the glass-paneled sides and back and the solid bottom were built up separately, the parts then being screwed together after coating the joints with white lead. The top was composed of 1-inch tongue-and-groove boards, also put on with screws. The vertically operating front window slid in a groove and could be adjusted to any desired height by metal pins inserted through holes in the corner of the case for the window to rest upon.

Cases which we have built in Manila differ somewhat in method of construction from the one described above, this being necessitated by the lack of suitable machines for rapid cabinet work. They are in no respect inferior, however. The framework consists of 2-by-2-inch tropical hardwood, preferably narra or guijo, and is built up of an upper and a lower rectangular frame with similar-sized members serving as corner posts. The horizontal members are lapped at the corners and the vertical posts are mortised entirely through them. This gives a very rigid frame. The double-strength window glass, or plate glass if one wishes to spend more for this item, is set into grooves running midway of the 2-by-2 framing. The glass is set in white lead. The top is made of 1-inch boards, splined.

One of our present cases (Plate 1) is 34 inches wide, 26 inches deep, and 26 inches high, this being a convenient size for handling several large culture bottles at a time. The fixed walls are made of single pieces of plate glass with a single unframed plate for the front, this sliding vertically in a groove in the corner posts. A much lighter case can be made of double-strength window glass, but the front pane needs to be set in a frame for additional strength.

When operating the case, the front window is raised and two boards having elliptical holes approximately 5 by 8 inches, spaced 15-inch centers, are inserted. The window rests in a groove in these. From this joint a curtain hangs somewhat below the bottom of the case. As an additional safeguard in preventing the entrance of contaminating organisms the arm openings in the boards are made smaller by tacking to the inside of the hole a pad of cotton surfaced with light cloth, leaving a slit for the hand.

It has been found that such a case is so tight that not sufficient air can enter to maintain a Bunsen flame for more than ten or fifteen minutes. It is therefore necessary to force compressed air into the case in considerable volume. This is a simple procedure at the Bureau of Science, since all the rooms are piped for this convenience. The compressed air is bubbled vigorously through a suction flask about one-fourth filled with a 1: 1000 mercuric chloride solution. It enters at the top of the case and is discharged horizontally along the roof. This supplementary apparatus serves three purposes; 1, supplies oxygen for the burner; 2, furnishes sterile moisture-laden air in which one can operate under aseptic conditions; and 3, the forced entrance of air creates a positive pressure from within and prevents the entrance of contaminating air by suction through the arm holes.

CELLULOID CYLINDERS FOR GROWING YOUNG PLANTS

Many of the plant diseases in the Philippines are so widely distributed and so little under control, even at propagation centers, that if one is to secure healthy plants for testing the pathogenicity of strains or species of the various organisms it becomes absolutely necessary to start with disease-free seed and grow the plants within a closed transparent container. Under the conditions of extreme insolation and high temperatures in the Tropics glass bell jars, or similar close containers, are very detrimental to the growth of the plants. The curved surface of a bell jar acts more or less as a condensing lens so that the accumulation of heat within becomes excessive; also the oxygen-carbon dioxide balance becomes seriously disarranged. As a result normal plants are rarely produced.

To mitigate this difficulty the writer introduced the use of celluloid cylinders (Plate 2) and these have proven very serviceable in our investigations on cacao, mango, truck crops,[1] etc. For the preparation of these cylinders we use standard-sized celluloid sheets, 20 by 50 inches, such as are used in automobile curtains. They are cemented with ethyl acetate, which acts as a welding-solvent for the material. A standard sheet makes a cylinder either 20 inches high by 15¾ inches in diameter or 40 by 6¼ inches, allowing ½ inch for the lap. They can be built up to any size, however, by the simple process of cementing the edges. This should be done carefully and rapidly, and the seams

[1] See Fajardo, T. G., and J. Marañon, Philip. Journ. Sci. 48 (1932) 133.

kept under pressure long enough for the softened materials to dry and consolidate.

The cylinders are kept true in form by the insertion of circles of heavy galvanized wire, bevelled and soldered at the joint, and placed about 1 or 1.5 inches from the ends. When in use a thin, sterile cloth of rather fine weave is tied over the top and the cylinder is pushed slightly into the soil of the pots containing the plants or germinating seeds. A layer of coarse sand covering the soil outside the cylinder will aid in preventing soil contamination but is hardly necessary if sterilized water be used during the growth of the plants. Needless to say, the soil and pots should both be sterilized before using.

Celluloid has been used in the United States, and probably elsewhere, for various purposes in plant pathology, and was first called to the writer's attention through its application by E. E. Hubert [2] as a protection, both in the greenhouse and in the field, for branches of forest trees after inoculation with rusts or other pathogenes.

In the Tropics the life of celluloid is rather short, usually around two years, after which it becomes quite brittle and cracks when carelessly handled. The cheaper grades of glass also depreciate rapidly on continuous exposure to varying atmospheric conditions, besides being subject to breakage at all times. A celluloid sheet of the size indicated costs in Manila 2.25 pesos (1.125 dollars), while a tall form of bell jar of much smaller size, 18 inches high, 10 inches in diameter, but of good quality glass, is listed at 10.80 dollars in the United States in case lots. Even though the latter were as suitable their cost would be prohibitive where several hundred may be needed at one time.

[2] Phytopath. 6 (1916) 447–449.

ILLUSTRATIONS

PLATE 1

FIG. 1. Plate-glass case now in use for plant-pathology work. Note the single vertically sliding pane in front and the suction flask at the top containing a 1:1000 solution of mercuric chloride. Compressed air is forced through this solution into the case.

2. Floor of the case, covered with sheet lead to prevent wetting of the boards.

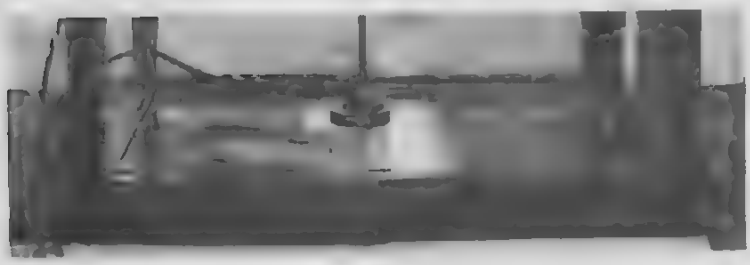
PLATE 2

FIG. 1. Celluloid cylinder 15¾ inches in diameter and 20 inches high. The sheet is cemented at the edges with ethyl acetate. The galvanized wire rings are inserted to hold the form.

2. One of the cylinders in use for growing mango seedlings. It is pressed slightly into the soil of the pot and the top is covered with finely woven cotton cloth.

3. Two cylinders of the same height but only 6¾ inches in diameter used for growing tomato plants. These plants are not of the bush type and therefore appear rather spindling.

1



2

PLATE 1

1 2 3

PLATE 2.

AVIAN MALARIA STUDIES, IV

HÆMOPROTEUS AND PLASMODIUM IN BIRDS OF LUZON PHILIPPINE ISLANDS [1]

By PAUL F. RUSSELL

Of the International Health Division of the Rockefeller Foundation

INTRODUCTION

Plasmodium and *Hæmoproteus* infections in birds are not at all uncommon. Huff(1) in 1927, for example, had records of *Plasmodium* infections in seventy-nine species of birds. He estimated that there have been twice as many records of *Hæmoproteus* infections. Hegner and Chu(2) published a survey of protozoan parasites in animals and plants of the Philippines and gave a list of 95 birds belonging to 47 species. In seven birds they found *Hæmoproteus* and in three *Plasmodium*.

It was a matter of interest, in connection with other avian malaria studies, to obtain further information as to the prevalence of *Hæmoproteus* and *Plasmodium* infections in Philippine birds. I am indebted to Mr. R. C. McGregor, chief of the division of zoölogy, Bureau of Science, first, for making it possible to take blood smears from birds caught by his field staff, and secondly, for the identification of bird species.

Between July, 1930, and December, 1931, blood smears were taken from over six hundred birds of more than forty species caught in the City of Manila, and in Bulacan, Rizal, and Nueva Ecija Provinces, Luzon Island, Philippine Islands. These smears were subjected to Giemsa's stain and examined with the results shown in Table 1.

From this table it will be noted that of the six hundred four birds examined sixty, or about 10 per cent, were positive for parasites of the genus *Plasmodium*. Organisms of the genus *Hæmoproteus* were found in one hundred seventeen, or in about

[1] This survey was made in the laboratory of malaria investigations, jointly supported by the Bureau of Science, Manila, and the International Health Division of the Rockefeller Foundation. Assisting in the microscopy were Misses Amparo Capistrano, chief microscopist, and Filomena Villacorta, microscopist. The drawings were made by Miss Lourdes Moskaira, special technician.

19 per cent of the smears. In one hundred six, or about 18 per cent of the cases, a mixed infection of *Plasmodium* and *Hæmoproteus* was diagnosed.

CLASSIFICATION

Wenyon(3) classifies the genera *Hæmoproteus* and *Plasmodium* as follows:

Phylum PROTOZOA Goldfuss, 1817.
Subphylum: PLASMODROMA Doflein, 1901.
Class SPOROZOA Leuckart, 1879.
Subclass COCCIDIOMORPHA Doflein, 1901.
Order COCCIDIIDA Labbé, 1899.
Suborder HÆMOSPORIDIIDEA
A. Family HÆMOPROTEIDÆ Doflein, 1916.
1. Genus *Hæmoproteus* Kruse, 1890.
2. Genus *Leucocytozoön* Danilewsky, 1890.
B. Family PLASMODIIDÆ Mesnil, 1903.
1. Genus *Plasmodium* Marchiafava and Celli, 1885.

HÆMOPROTEUS

Parasites diagnosed as belonging to the genus *Hæmoproteus* were found, as shown in Table 1, in the following birds:

Aluco longimembris. Grass owl.
Excalfactoria lineata. Island painted quail.
Munia cabanisi. Cabanis's weaver.
Numenius variegatus. Eastern whimbrel.
Rallina eurizonoides. Philippine banded crake.
Totanus eurhinus. Asiatic redshank.
Turnix fasciata. Philippine button quail.

In Plate 1 are figured *Hæmoproteus* organisms as seen in the grass owl and the island painted quail. No marked differences in morphology were observed between any of the *Hæmoproteus* of these Philippine birds and the illustrations given by Wenyon(4) of *Hæmoproteus columbæ* Celli and Sanfelice, 1891. But it cannot be stated that the species observed is or is not the classical species. No transmission experiments were done with the fly *Lynchia maura.* Blood inoculations from birds with *Hæmoproteus* infections as usual did not result in the transmission of this parasite.

PLASMODIUM

As noted in Table 1, *Plasmodium* was represented in the following birds:

Aluco longimembris. Grass owl.
Excalfactoria lineata. Island painted quail.
Munia cabanisi. Cabanis's weaver.

Numenius variegatus. Eastern whimbrel.
Rallina eurizonoides. Philippine banded crake.
Totanus eurhinus. Asiatic redshank.
Turnix fasciata. Philippine button quail.

Morphologically, these avian plasmodia all seem to belong to one or the other of two species; namely, *P. elongatum* Huff, 1930, and *P. capistrani* sp. nov., 1932. In three cases of seven attempts plasmodium was transmitted by blood inoculations to canaries (*Serinus canarius*). The first transmission was made August 4, 1930, from an island painted quail (*Excalfactoria lineata*). The plasmodium established itself in the canary and has been successfully propagated from that time to the present (November, 1931). This plasmodium apparently belongs to a new species. In another report(5) it has been called *P. capistrani* sp. nov., 1932, and accompanying the description are some biological notes which, I believe, indicate that a specific status is justified.

November 7 a second successful transmission of *P. capistrani* was made from an island painted quail into two canaries, C12 and C13.

July 31, 1931, a successful transmission was made into a canary from the Philippine button quail (*Turnix fasciata*). This plasmodium, which has an elongate gametocyte, is believed to be *P. elongatum* Huff, 1930. In the first place it is morphologically similar in its asexual development and in its crescentic gametocytes (see Plate 2). In the second place it has not been possible, in three attempts, to cross-infect in either direction this plasmodium with one known to be *P. elongatum* Huff. The known species was secured through the courtesy of Dr. C. G. Huff in 1929 and has been carried along in the laboratory since that time.

REMARKS

No parasites of the genus *Leucocytozoon* were observed. No blood parasites were found in 130 mountain sparrows (*Passer montanus*), a common bird in Manila. *Plasmodium relictum* Grassi and Feletti, 1891, was not diagnosed, although it is reported as common in tropical and subtropical countries. It is possible, of course, that in some of the quail this plasmodium was present as well as *P. capistrani* sp. nov. It is doubtful if the two species could be distinguished in some stages of development. This question and that of validity of species in avian malaria, are considered in another paper.(5)

TABLE 1.—*Wild birds examined for blood parasites.*

Bird.			Birds examined.	Plasmodium.		Hæmoproteus.		Mixed infection.	
Serial No.	Scientific name.	Common name.		Birds positive.	Percentage positive.	Birds positive.	Percentage positive.	Birds positive.	Percentage positive.
1	*Acanthopneuste borealis*	Northern willow warbler	1	0	0	0	0	0	0
2	*Accipiter confusus*	Philippine sparrow hawk	1	0	0	0	0	0	0
3	*Accipiter manillensis*	do	1	0	0	0	0	0	0
4	*Aluco longimembris*	Grass owl	3	1	33	2	67	1	33
5	*Amaurornis olivacea*	Philippine waterhen	1	0	0	0	0	0	0
6	*Anas* sp	Domestic duck	12	0	0	0	0	0	0
7	*Bubulcus coromandus*	Cattle egret	2	0	0	0	0	0	0
8	*Cephalopheneus nasutus*	Large-nosed shrike	2	0	0	0	0	0	0
9	*Chalcophaps indica*	Indian bronze-winged dove	4	0	0	0	0	0	0
10	*Cinnyris jugularis*	Yellow-breasted sunbird	1	0	0	0	0	0	0
11	*Cyornis philippinensis*	Philippine cyornis	1	0	0	0	0	0	0
12	*Egretta garzetta*	Little white egret	2	0	0	0	0	0	0
13	*Excalfactoria lineata*	Island painted quail	158	46	29	96	61	95	60
14	*Gallinago megala*	Swinhoe's snipe	23	0	0	0	0	0	0
15	*Geopelia striata*	Barred ground dove	3	0	0	0	0	0	0
16	*Halcyon gularis*	White-throated kingfisher	1	0	0	0	0	0	0
17	*Haliastur intermedæ*	Malayan brahminy kite	2	0	0	0	0	0	0
18	*Hypotænidia philippensis*	Pectoral rail	5	0	0	0	0	0	0
19	*Hypotænidia striata*	Blue-breasted rail	13	0	0	0	0	0	0
20	*Hypotænidia torquata*	Philippine rail	4	0	0	0	0	0	0
21	*Hypothymis occipitalis*	Black-naped flycatcher	1	0	0	0	0	0	0
22	*Izobrychus astrologus*	Little yellow bittern	1	0	0	0	0	0	0
23	*Lalage melanoleuca*	Black and white lalage	1	0	0	0	0	0	0
24	*Leucotreron leclancheri*	Black-chinned fruit pigeon	1	0	0	0	0	0	0
25	*Limnobænus fuscus*	Ruddy crake	2	0	0	0	0	0	0

25	*Mirafra philippinensis*	Philippine bush lark	1	0	0	0	0	0	0
27	*Munia cabanisi*	Cabanis's weaver	61	1	2	3	5	2	3
28	*Munia jagori*	Philippine weaver	12	0	0	0	0	0	0
29	*Numenius variegatus*	Eastern whimbrel	24	2	8	1	4	1	4
30	*Nycticorax nycticorax*	Common night heron	3	0	0	0	0	0	0
31	*Oriolus acrorhynchus*	Philippine oriole	1	0	0	0	0	0	0
32	*Orthotomus derbianus*	Derby's tailorbird	1	0	0	0	0	0	0
33	*Otomela lucionensis*	Gray-headed shrike	2	0	0	0	0	0	0
34	*Padda oryzivora*	Java sparrow	4	0	0	0	0	0	0
35	*Passer montanus*	Mountain sparrow	130	0	0	0	0	0	0
36	*Phapitreron leucotis*	Northern white-eared pigeon	1	0	0	0	0	0	0
37	*Pluvialis fulvus*	Pacific golden plover	1	0	0	0	0	0	0
38	*Pratincola caprata*	Pied chat	1	0	0	0	0	0	0
39	*Rallina eurizonoides*	Philippine banded crake	10	1	11	5	56	1	11
40	*Rostratula capensis*	Painted snipe	18	0	0	0	0	0	0
41	*Spilornis holospilus*	Philippine serpent eagle	1	0	0	0	0	0	0
42	*Sturnia sinensis*	Gray-backed starling	1	0	0	0	0	0	0
43	*Totanus surhinus*	Asiatic redshank	5	1	20	1	20	1	20
44	*Turnix fasciata*	Philippine button quail	31	8	25	9	29	5	16
45	*Turnix ocellata*	Spotted button quail	21	0	0	0	0	0	0
46	*Turnix whiteheadi*	Whitehead's button quail	4	0	0	0	0	0	0
	Total [a]		604	60	10	117	19	106	18

[a] Species examined, 46; species with malaria plasmodia, 7.

SUMMARY

The results of the examination of some six hundred blood smears from wild-caught birds are reported. In a number of cases parasites of the genera *Hæmoproteus* and *Plasmodium* were found. These parasites apparently belong to the species *H. columbæ* Celli and Sanfelice, 1891; *P. elongatum* Huff, 1930; and *P. capistrani* sp. nov., 1932.

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AVIAN MALARIA STUDIES, V

PLASMODIUM CAPISTRANI SP. NOV., AN AVIAN MALARIA PARASITE IN THE PHILIPPINES [1]

By PAUL F. RUSSELL

Of the International Health Division of the Rockefeller Foundation

TWO PLATES AND ONE TEXT FIGURE

INTRODUCTION

In the course of a survey of *Hæmoproteus* and *Plasmodium* infections in Philippine birds, as reported in a previous paper, (1) a parasite was encountered in a quail which is apparently a new species of plasmodium. This organism has been observed for more than a year and is now being presented as *Plasmodium capistrani* sp. nov.

NOMENCLATURE

There is a great deal of confusion at present as to the number of species and the proper names of the avian malaria parasites. The situation has become so complex that it urgently requires official clarification. In this paper the question will not be considered to any greater extent than seems absolutely necessary as a background. Unfortunately, it will not be possible to relieve any of the confusion. However, it is believed that the specificity of the new parasite of bird malaria reported hereunder has been proved, so that there need be no fear of further beclouding the issue.

Six species of avian malaria parasites have, I believe, justifiable claims to specific names at the present time. They are as follows:

[1] This study was made in the laboratory of malaria investigations, jointly supported by the Bureau of Science, Manila, and the International Health Division of the Rockefeller Foundation. The author was assisted in microscopy by Misses Amparo Capistrano, chief microscopist, and Filomena Villacorta, microscopist; in mosquito transmission by Mr. Andres Nono, chief field assistant. The drawings are the work of Miss Lourdes Moskaira, special technician. This paper was read before a regular meeting of the Philippine Society of Parasitology, November 21, 1931.

1. *Plasmodium relictum* Grassi and Feletti, 1891. This is, I believe, identical with the parasite isolated by Whitmore in 1913. It is *P. inconstans* Hartman, 1927. This parasite has been and is often called *P. præcox.* It has had an average incubation period in one hundred canaries, in my experience, of eight or nine days. The gametocytes are not crescentic and their pigment granules are usually somewhat more spherical than cylindrical.

2. *Plasmodium cathemerium* Hartman, 1924. This parasite, like *P. relictum,* does not have crescentic gametocytes. The pigment granules in *P. cathemerium* are usually somewhat more cylindrical than spherical. The average incubation period in several hundred canaries, in my experience, has been about five days. Cross inoculations can be done between *P. relictum* and *P. cathemerium.* The relations, however, are not reciprocal, for Gingrich(2) reports that *P. cathemerium* inoculated into birds with latent infections of *P. relictum* produced no demonstrable infection but subinoculations showed both *P. cathemerium* and *P. relictum.* On the other hand, in his experience, *P. relictum* inoculated into birds with latent infections of *P. cathemerium* produced an infection somewhat lower than control infections in normal birds.

3. *P. rouxi* Sergent and Catanei, 1928.

4. *P. circumflexum* Kikuth, 1931. Both *P. rouxi* and *P. circumflexum* have been studied by Huff(3) in association with *P. relictum, P. cathemerium,* and *P. elongatum* and he is convinced of their specific validity.

5. *Plasmodium elongatum* Huff, 1930. This parasite is distinguished by its crescentic gametocytes. It has a longer incubation period, averaging in one hundred canaries, in my experience, ten days. This species is *P. præcox* of Huff, 1926, of Hartman, 1927. It is thought by some to be *P. præcox* of Grassi and Feletti, 1890. It is certainly distinct from *P. relictum* and *P. cathemerium* described above. Cross infection with either or both of those species can be done.

6. *Plasmodium capistrani* sp. nov., described hereunder.

Other avian plasmodia have been described; for example, *P. majoris* of Laveran, 1902 and *P. vaughani* of Novy and McNeal, 1907. It seems impossible, however, at the present time to give these last-named parasites more than a doubtful specific status.

For discussions of one phase or another of this question of the specific names and status of the avian malaria plasmodia refer to Hartman,(4) Huff,(5, 6, 7) and Schuurman.(8)

DESCRIPTION

PLASMODIUM CAPISTRANI sp. nov. Plates 1 and 2.

Morphology.—With Giemsa's stain the parasites are clearly distinguished in the cytoplasm of the red blood cell. The trophozoites are usually at either end of the erythroblast or, frequently, of the erythrocyte. Occasionally two, and rarely three, young trophozoites have been seen in the same blood cell. The older parasites tend to displace or completely to dislodge the nucleus of the red cells. Pigment is usually present and seems to be more abundant than in the other three species of avian malaria parasites. It is more often cylindrical or cone-shaped than spherical and it tends to clumping. Vacuoles are not uncommon. Segmenting forms are common in the peripheral blood and there are from eight to sixteen merozoites.

Both microgametocyte and macrogametocyte are spherical in shape. No crescentic gametocytes are formed. The gametocytes are usually in the apex of the cell, which is often distorted. The nucleus of the red cell is always pushed aside and may lie transversely or it may be absent. The cytoplasm of the microgametocyte stains more faintly blue than that of the macrogametocyte with Giemsa's stain. Chromatin is abundant in each and tends to be somewhat scattered, although it is sometimes more compactly arranged in the macrogametocyte. Pigment is abundant in both gametocytes and is scattered throughout the cytoplasm. It seems to be more prominent than in the other species of malaria plasmodia (see Plate 1).

Oökinetes have not been studied. Oöcysts are similar to those of other malaria plasmodia, as are also the sporozoites (see below and also Plates 2 and 3).

Type locality.—Novaliches, Rizal Province, Philippine Islands.

Type host.—*Excalfactoria lineata,* island painted quail.

PATHOGENICITY

Reference to Table 1 reveals some interesting points in regard to the pathogenicity of *P. capistrani* in canaries. It will be seen that in the first twenty-five attempts to infect canaries by blood inoculation (birds C1 to C33 August 4, 1930, to July 8, 1931), there were seven (28 per cent) negative results. In the next thirty-nine attempts there were only six (15 per cent) failures.

But the most striking feature is the fact that among the eighteen successful infections in the first twenty-five attempts,

TABLE 1.—*Clinical data from canaries infected with Plasmodium capistrani sp. nov.*

[*Modes of infection:* 1. By needle inoculation of blood-saline mixture intramuscularly. 2. By the bite of *Culex quinquefasciatus* (*fatigans*). 3. By needle inoculation of saline suspension of macerated thorax tissues of *Culex quinquefasciatus* (*fatigans*). Numbers missing from this table were on birds which either died within four days of inoculation or were used with other plasmodia than *P. capistrani* sp. nov. All birds used with *P. capistrani* and living more than four days after inoculation have been included in the table.]

Canary.	Inoculation.				Results of examinations of blood smears.			
	Date.	Mode.	Source of inoculum.	Result.	Negative.	+	++	+++
	1930							
C1	Aug. 4	1	EL5	P	Aug. 4 to 14	Aug. 15 to 20		
C2	Aug. 18	1	C1	P	Aug. 18, 24	Aug. 25 to 30		
C3	do	1	C1	P	Aug. 18 to 26	Aug. 27		
C4	Aug. 28	1	C2	P	Aug. 28 to Sept. 2	Sept. 3 to 11		
C5	do	1	C2	P	Aug. 28 to Sept. 7	Sept. 8, 9		
C8	Sept. 5	1	C4	P	Sept. 5 to 19	Sept. 20, 24		
C9	do	1	C4	P	Sept. 5 to 11 and Sept. 13–18	Sept. 12 and Sept. 19–24		
	1931							
C18	Feb. 16	1	C4	N	Feb. 16 to Mar. 4			
C19	do	1	C4	P	do	Mar. 5		
C20	Mar. 5	1	C19	N	Mar. 5 to Apr. 4			
C20	Mar. 23	1	C1	P	do	Apr. 6 to 11		
C21	Mar. 5	1	C19	N	do			
C21	Mar. 23	1	C1	N	do			
C22	do	1	C5	N	Mar. 23 to 31			
C23	do	1	C5	N	Mar. 23 to Apr. 1			
C24	Apr. 8	1	C20	P	Apr. 8 to 18	Apr. 20 to 25		
C25	do	1	C20	P	Apr. 8 to 16	Apr. 18 to 22		
C26	Apr. 21	1	C24	P	Apr. 21 and 28	Apr. 29 to May 4		
C27	do	1	C24	P	Apr. 21 to May 2	May 4 and 11		
C28	May 11	1	C26	P	May 11 to 22	May 24 to June 1		

C29	----do----	1	C26	N	May 11 to July 16				
C29	July 16	1	C25	P	May 11 to July 22	July 23 to 29			
C30	June 1	1	C28	P	June 1 to 9	June 11 and 13			
C31	----do----	1	C28	P	June 1 to 15	June 17 to 23			
C33	July 8	1	C5	P	July 8 to 17	July 18			
C34	July 16	1	C25	P	July 16 to 22	July 23 to 29			
C35	July 27	1	C34	P	July 27 to Aug. 3	Aug. 4			Aug. 8, 10, 11, 12
C36	----do----	1	C34	P	July 27 to Aug. 3	----do----	Aug. 11		Aug. 5, 7
C39	Aug. 5	1	C5	P	Aug. 5, 13	Aug. 14, 15			
C40	----do----	1	C5	P	Aug. 5, 11	Aug. 12			
C46	Aug. 31	2	C35	N	Aug. 31 and Sept. 7–12				
C47	Sept. 1	2	C35	P	Sept. 1 to 8	Sept. 9, 10			
C48	----do----	2	C35	P	----do----	Sept. 9 to 12			
C49	Sept. 4	3	C35	N	Sept. 4 to 16				
C52	Sept. 8	3	C35	N	Sept. 8 to Oct. 2				
C53	Sept. 15	1	C48	P	Sept. 15 to 21	Sept. 22	Sept. 30		
C54	----do----	1	C48	P	Sept. 15 and 22	Sept. 23 to Oct. 2			
C66	Sept. 26	1	C29	P	Sept. 26 and Oct. 4	Oct. 5 and 7			
C67	----do----	1	C29	P	Sept. 26 and Oct. 5	Oct. 6–9	Oct. 17, 20		Oct. 13
C68	----do----	1	C29	P	----do----	Oct. 6, 7			Oct. 9
C69	----do----	1	C29	P	----do----	----do----			
C71	Oct. 12	2	C48	P	Oct. 12, 20	Oct. 21			
C73	Oct. 15	3	C48	P	Oct. 15, 26, 28, 29	Oct. 29, 30			
C77	----do----	3	C48	N	Oct. 15, 27–31 and Nov. 2–9				
C78	----do----	3	C48	P	Oct. 15, 27–31	Nov. 1, 2			Nov. 4
C80	----do----	3	C48	N	Oct. 15, 27–31 and Nov. 3–9				
C81	----do----	3	C48	N	----do----				
C82	----do----	2	C48	P	Oct. 15, 24, 25, 26	Oct. 27, 29, 31			
C83	----do----	2	C48	P	Oct. 15, 24	Oct. 25	Oct. 27, 29		
C84	Oct. 23–24	2	C48	N	Oct. 23 and Nov. 3, 5, 7, 9, 10, 13, 16, 18, 20, 24				
C85	----do----	2	C48	N	----do----				
C86	Oct. 27	1	C71	P	Oct. 27, and Nov. 1–3	Nov. 4			
C87	----do----	1	C71	P	Oct. 27, and Nov. 1		Nov. 2		
C88	----do----	1	C71	P	----do----		Nov. 2, 3		

TABLE 1.—*Clinical data from canaries infected with Plasmodium capistrani sp. nov.*—Continued.

Canary.	Inoculation.				Results of examinations of blood smears.			
	Date.	Mode.	Sources of inoculum.	Result.	Negative.	+	++	+++
	1931							
C89	Nov. 2	1	C83	P	Nov. 2, 7, 8	Nov. 9, 10		
C90	do	1	C83	P	do	do	Nov. 12	
C91	do	1	C83	P	Nov. 2	Nov. 7, 9, 10	do	
C92	do	1	C83	P	Nov. 2, 7, 8, 9	Nov. 10	do	Nov. 16
C96	Nov. 13	1	C39		Nov. 13, 19, 21, 23, 25			
C97	do	1	C39	P	do	Nov. 25		
C98	do	1	C39		do			
C99	do	1	C67	P	Nov. 13, 19	Nov. 21, 23		
C100	do	1	C67	P	do	Nov. 21	Nov. 23	
D1	do	1	C67	P	do	do	do	

Canary.	Results of examinations of blood smears—Continued.				Length of prepatent period.	Died.	Remarks.
	++++	+++++	+	Negative.			
					Days.		
C1				Aug. 21, 1930 to Mar. 30, 1931	11	July 2, 1930	
C2				Sept. 16, 1930 to Mar. 18, 1931	7	Mar. 20, 1931	
C3					9	Aug. 28, 1930	
C4				Sept. 13, 1930 to Mar. 18, 1931	6	Mar. 20, 1931	
C5			June 30 and July 8, 1931	Sept. 11, 1930 to Mar. 23, July 22 and Aug. 4	11	Aug. 12, 1931	
C8					15	Sept. 25, 1930	

C9			Feb. 10, 1931	Sept. 30, 1930. Oct. 22, 1930. Jan. 2, 1931	7	Feb. 12, 1931	All dates 1931 hereaf.
C18						Mar. 5	
C19				Mar. 6 to 19	16	Mar. 20	
C20						June 30	
C20				June 30	14	June 30	
C21						Apr. 5	
C21						do	
C22						Apr. 1	
C23						Apr. 3	
C24				July 8	11 or 12	July 20	
C25			July 8, 14, 16, 22, Aug. 10	July 24	9 or 10	Aug. 30	
C26				May 11, July 8, Aug. 4, Sept. 23 to Oct. 9	7		Alive Nov. 25, 1931.
C27			Aug. 4	July 8	12 or 13	Aug. 10	
C28				June 30	12 or 13	July 3	
C29						Nov. 22	
C29			Sept. 29	Aug. 10, Sept. 26 to 28	7	do	
C30				June 15 to 18	9 or 10	June 28	
C31					15 or 16	June 27	
C33			July 23 to 25	July 20–22, Aug. 10	10	Aug. 17	
C34	July 31, Aug. 1 and 3.		Aug. 5 and 10	Aug. 30	7	Sept. 13	
C35	Aug. 5, 7, 13	Aug. 6, 14, 15			8	Aug. 16	
C36	Aug. 6		Aug. 8, 10, 12	Sept. 15	8	Nov. 2	
C39			Nov. 17	Nov. 18	9		Alive Nov. 25, 1931.
C40	Aug. 19, 21	Aug. 14, 15	Sept. 26	Sept. 27, 28, 29	7	Nov. 12	
C46						Sept. 13	
C47			Sept. 14	Sept. 11, 12, 15–19	8	Oct. 13	
C48	Sept. 14	Sept. 15 to 21.			8	Sept. 28	
C49				Nov. 14			Alive Nov. 25, 1931.
C52						Oct. 18	
C53	Sept. 28	Sept. 23, 25	Oct. 2		7	do	
C54					8	do	

TABLE 1.—*Clinical data from canaries infected with Plasmodium capistrani sp. nov.*—Continued.

Canary.	Results of examinations of blood smears—Continued.				Length of prepatent period.	Died.	Remarks.
	++++	+++++	+	Negative.			
					Days.		
C66	Oct. 9		Oct. 13, 15, 17, 20, 24	Nov. 17	9		Alive Nov. 25, 1931.
C67	Oct. 24		Oct. 15	Nov. 13, 17	10		Do.
C68			Oct. 13, 15, 17, 20	Oct. 24	10		Do.
C69			Oct. 13, 15, 17, 20, 24	Oct. 9, Nov. 17	10		Do.
C71		Oct. 26, 27, 28, 30			9	Oct. 31	
C73				Nov. 1, 2, 3, 5, 6, 9	14	Nov. 11	
C77						do	
C78	Nov. 6	Nov. 7, 9			17	Nov. 9	
C80				Nov. 14		Nov. 19	
C81				do		Nov. 15	
C82				do	12		Alive Nov. 25, 1931.
C83			Oct. 31	Nov. 2 and 14	10		Do.
C84							Do.
C85							Do.
C86	Nov. 6, 7		Nov. 9		8	Nov. 11	
C87	Nov. 3	Nov. 4			6	Nov. 5	
C88					6	Nov. 4	
C89	Nov. 12				7	Nov. 19	
C90	Nov. 13	Nov. 14, 16			7		Alive Nov. 25, 1931.
C91	Nov. 14	Nov. 16, 20			5	Nov. 22	
C92	do				8		Alive Nov. 25, 1931.
C96							Do.
C97					11 or 12		Do.
C98							Do.
C99					7 or 8		Do.
C100					7 or 8		Do.
D1	Nov. 24				7 or 8		Do.

blood smears were never more than one plus. At no time during repeated passages from the first recovery of the parasite in August, 1930, until July, 1931, was a blood smear ever more than one plus in degree of infection.

Smears were diagnosed in accordance with the following rules:

+	Positive in thirty minutes or less.
++	Two parasites per field found twice in one minute.
+++	Three parasites per field found more than three times in one minute.
++++	Four parasites per field found more than four times in one minute.
+++++	Ten or more parasites per field on the average.

What this scheme actually means may be estimated from Table 2.

TABLE 2.—*Intensity grouping of blood smears.*

Groups.	Smears counted.	Parasites per 10,000 red blood cells.
+	74	15
++	19	170
+++	18	320
++++	16	560
+++++	44	1,320

However, beginning in bird C34 infected July 16, 1931, this *P. capistrani* began to show an increased pathogenicity for canaries. Bird C34, for example, was + + + + July 31, August 1, and 8; canary C35 was + + + August 8, 10, 11, and 12; + + + + August 5, 7, and 13; + + + + + August 6, 14, and 15. Thereafter, it became the usual thing to find these more intense infections.

Reference to the chart shows that there were two main lines of transmission from bird C1. One line was through C2, the other through C20. It is interesting that along each line it was on the fourth passage from the original quail, EL5, that the parasite began to show an increase in pathogenicity for the canary.

PREPATENT PERIOD

Some information about the prepatent period may be gained from Table 1. This period has varied considerably in *P. capistrani*, as it does in all of the avian malarias when infection is transferred by intramuscular injections. It is not safe to draw

any conclusion as to a change in the incubation period of this parasite during the period of observation. The average incubation period is approximately nine days.

PERIODICITY

A brief attempt has been made to determine the periodicity of *P. capistrani* but, like *P. relictum*, its periodicity is not clearly defined. In Tables 3 and 4 are presented the results of two series of parasite counts in this connection, made on birds C40 and C90. There is no well-marked cycle revealed in these two-hourly parasite counts. Before making any definite statement in this regard it would be necessary to make such a study as that of Taliaferro.(9)

TABLE 3.—*A series of parasite counts on bird C40 (infected with P. capistrani) to determine periodicity, if any, of segmentation.*

Date.	Hour.	Red cells counted.	Segmenters and pre-segmenters counted.	Total parasites counted.	Parasites per 10,000 red blood cells.	Segmenters and pre-segmenters per 10,000 red blood cells.
	a. m. p. m.					
August 14, 1931	12 --	187	0	19	1,016	0
Do	-- 2	330	3	26	787	91
Do	-- 4	200	4	30	1,500	200
Do	-- 6	211	8	28	1,327	379
Do	-- 8	217	8	35	1,613	369
Do	-- 10	219	5	31	1,416	228
Do	-- 12	235	5	33	1,404	213
August 15, 1931	4 --	206	5	34	1,650	243
Do	6 --	204	5	27	1,324	245
Do	8 --	216	3	27	1,250	139
Do	10 --	199	2	28	1,407	101
Do	12 --	201	1	43	2,139	50
Do	-- 2	210	4	35	1,667	190
Do	-- 4	210	5	43	2,048	238
Do	-- 6	211	1	36	1,706	47
Do	-- 8	204	3	29	1,422	147
Do	-- 10	171	3	46	2,690	175
Do	-- 12	199	4	41	2,060	201
August 16, 1931	2 --	218	3	38	1,743	138
Do	4 --	196	2	44	2,245	102
Do	6 --	211	4	41	1,943	190
Do	8 --	215	4	32	1,483	186
Do	10 --	209	3	37	1,770	145
Do	12 --	227	3	47	2,070	132

TABLE 4.—*A series of parasite counts on bird C90 to determine periodicity, if any, of segmentation.*

Date.	Hour.	Red cells counted.	Segmenters and pre-segmenters counted.	Parasites counted.	Parasites per 10,000 red blood cells.	Segmenters and pre-segmenters per 10,000 red blood cells.
	a. m. p. m.					
November 12, 1931	8 --	3,465	3	23	27	7
Do	10 --	5,848	1	22	38	2
Do	12 --	7,452	4	24	32	7
Do	-- 2	5,658	0	22	39	7
Do	-- 4	2,960	2	21	71	14
Do	-- 6	2,210	2	25	113	27
Do	-- 8	2,910	3	26	89	14
Do	-- 10	2,937	2	24	82	7
Do	-- 12	1,900	2	29	153	26
November 13, 1931	2 --	962	1	23	239	21
Do	4 --	541	4	23	425	92
Do	6 --	536	1	23	429	93
Do	8 --	518	3	23	444	116
Do	10 --	488	2	24	492	41
Do	12 --	347	2	22	634	173
Do	-- 2	321	0	21	654	31
Do	-- 4	332	2	23	693	60
Do	-- 6	336	3	21	625	89
Do	-- 8	251	1	26	1,036	40
Do	-- 10	181	4	21	1,160	276
Do	-- 12	203	1	23	1,133	99
November 14, 1931	2 --	184	3	22	1,196	163
Do	4 --	185	4	27	1,459	216
Do	6 --	174	2	24	1,379	115
Do	8 --	222	1	24	1,081	90
Do	10 --	206	2	21	1,009	146
Do	12 --	182	1	23	1,264	110

MOSQUITO TRANSMISSION

Bird C35 was exposed to the bites of some *Culex quinquefasciatus* (*fatigans*) mosquitoes during the nights of August 11 and 12, 1931. Blood smears from this bird were + + + for *P. capistrani* each day. There were, respectively, forty-four and fifty-four gametocytes per ten thousand red blood cells these days. The dissection record of the mosquitoes is shown in Table 5. Of the fifteen mosquitoes dissected, eight and nine days after feeding, seven were found to have oöcysts (see Plate 2).

The salivary glands of one hundred thirty-eight mosquitoes were dissected and eleven were found to contain sporozoites, a rate of about 8 per cent.

TABLE 5.—*Dissection of Culex quinquefasciatus (fatigans) mosquitoes after feeding on bird C35, positive for P. capistrani.*

Days after feeding.	Mosquitoes.		
	Dissected.	With oöcysts.	With sporozoites.
8[a]	5	2	0
9	10	5	0
17	10	[b]	0
19	5	[b]	3
21	25	[b]	1
23	5	[b]	1
26	5	[b]	0
27	19	[b]	3
28	2	[b]	0
29	26	[b]	1
30	26	[b]	2
Total	138		11

[a] Temperatures varied between 28° and 33° C. and the relative humidity between 85 and 96 during this period.

[b] No examination for oöcysts.

In Plates 1 and 3 are shown an oöcyst and sporozoites, respectively, of *P. capistrani* in *Culex quinquefasciatus*. The oöcyst was photographed nine and one-half days after a blood meal on C35. The temperature had varied in the meantime between 28° and 29.2° C., and the relative humidity between 85 and 96. Not enough oöcysts have been measured to give average sizes. The one photographed measured 38 and 43 μ in diameter. This is relatively large compared to the oöcysts of *P. cathemerium* and *P. relictum*.

The sporozoites were photographed twenty-four days after the mosquito had a blood meal from C35. Temperature had varied between 28.1° and 30.1° C. and relative humidity between 86 and 96 during this period. As noted in Table 5 the first sporozoites were found after nineteen days in mosquitoes infected with *P. capistrani*. Not enough dissections have been done to fix this development period exactly, but it would seem to be longer than the corresponding period in *P. cathemerium* and *P. relictum*.

Two negative birds, C47 and C48, were placed in a cage with these mosquitoes on each night from September 1 to 7, that is eleven to seventeen days after the mosquitoes had fed on C35. Blood smears from C47 were negative September 1 and 8, + September 9 and 10, negative September 11 and 12, + September 14, and negative September 15, 16, 17, 18, and 19. This bird died October 13.

Smears from C48 were negative September 1 and 8, were + September 9, 10, 11, and 12; + + + + September 14; + + + + + September 15, 16, 17, 18, 20, and 21. This bird died September 23.

In a similar way birds C71, C82, and C83 were infected by the bites of mosquitoes which had fed twenty-five days previously on C48. Bird C71 was exposed on one night only, October 12, and became + + + + + for *P. capistrani* October 26, dying October 31.

Birds C82 and C83 were exposed on one night only, October 15, to mosquitoes which had fed on C48 twenty-three days previously. Bird C82 was + October 27, 29, and 31. It was negative October 15, 24, 25, 26, and November 14. C83 was + October 25, 31, and November 14; + + October 27 and 29, negative October 15, 24, and November 2.

October 15, seventy-five mosquitoes, which had fed twenty-eight days previously on C48, were dissected, and the thorax of each insect was added to normal saline solution, the entire mixture being ground up as fine as possible. From this mixture 0.2 cubic centimeter each was injected into ten birds, C72 to C81. Three of these birds, C72, C76, and C79, died within a few days. Five of the remaining seven remained negative (two of these five with the help of chinoplasmin). Two birds became infected, C73 and C78. Bird C73 was + October 29 and 30. It was negative October 15, 26, 28, November 1, 2, 3, 5, 6, and 9. This bird died November 11. Bird C78 was + November 1 and 2; + + + November 4; + + + + November 6; + + + + + November 7 and 9. Smears were negative October 15, 27, 29, and 31. This bird died November 9.

Plasmodium capistrani has, therefore, been transmitted in three ways—by direct needle inoculation of infected blood, by needle inoculation of sporozoites, and by the natural bite of infected culex mosquitoes.

CROSS INFECTIONS

It seems well substantiated that superinfection with a single species of avian malaria is not possible. While a bird is infected with one species these parasites confer "premunition"(10) to another infection with the same species. If inoculation be attempted with another species, however, superinfection usually takes place. Therefore, cross infections were attempted between *P. capistrani* and three other recognized species of avian malaria; namely, *P. elongatum, P. relictum,* and *P. cathemerium.*

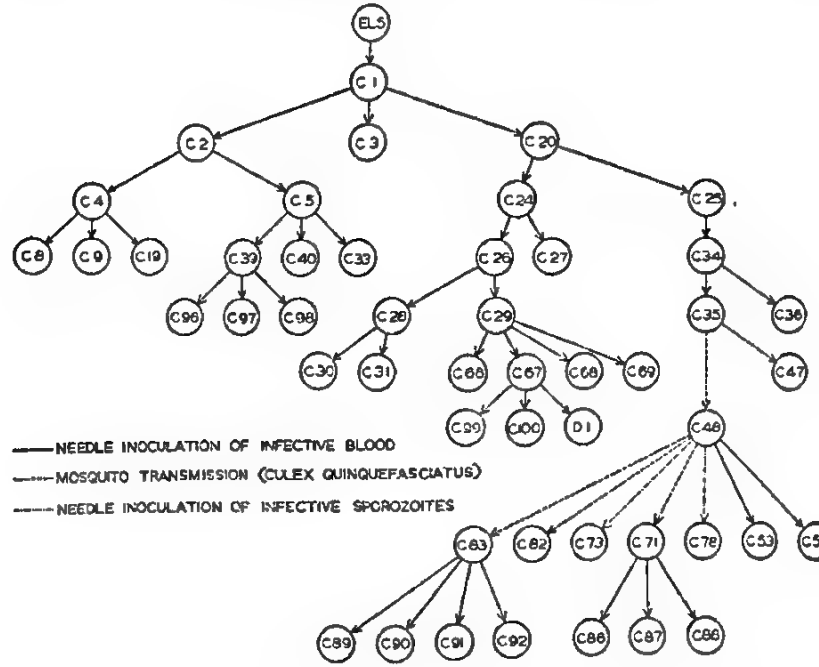

FIG. 1. Lines of transmission of *Plasmodium capistrani* sp. nov.

For these three parasites I am indebted to Dr. C. G. Huff from whom I received them in 1929. I have propagated them in canaries since that time. In previous papers(11, 12, 13) reporting experiments in which I used *P. cathemerium*, I have mistakenly referred to *P. cathemerium* as the Boston strain of Doctor Huff. It is probable that the Boston strain is *P. relictum*. The *P. relictum* used in the following cross infections comes from the original Whitmore strain. The *P. cathemerium* is descended from the original Hartman strain and the *P. elongatum* from the original Huff strain. They seem to have remained true to their specific characters.

Plasmodium capistrani has been successfully cross inoculated with all three of these plasmodia. In one series, birds with *P. capistrani* infections have been recipients of one or more of the other species. In another series birds having infections with the other species have received *P. capistrani* without evidence of premunition. Biologically, therefore, as well as morphologically, there seems reason to believe that *P. capistrani* is a valid species. There follow the protocols of the birds used in cross-infection experiments:

Bird L11.

This bird received intramuscularly an infective inoculum of blood-saline mixture from X38 April 18, 1931. Blood smears from L11 were negative April 18 and 28. They were positive for *P. cathemerium* April 29 and 30, were negative May 8 and 9, June 17, July 24, August 3, 4, and 5.

July 24 this bird (L11) received intramuscularly an infective inoculum of blood-saline mixture from C25, a bird whose blood, July 22, had been + for *P. capistrani* although negative July 24. Blood smears from L11 were + for *P. capistrani* August 6, 7, and 8, + + + August 10, + + + + + August 11 and 12, + + + + August 14, 15, 17, + + August 19 and 21. This bird was still alive November 15, 1931.

Bird L76.

This bird received intramuscularly an infective inoculum of blood-saline mixture from L62 June, 1931. Blood smear was negative June 1. Smears were + + + + June 8, 9, and 10 for *P. cathemerium*, + + June 11, 12, and 13, + June 15. September 16 this bird was subjected to the loss of 0.5 cubic centimeter of blood in some experimental studies on relapse. Yet in spite of this severe hæmorrhage and repeated thirty-minute examinations smears from L76 were negative September 16, 17, 18, 19, 21, 22, and 23. One parasite in thirty minutes was found September 24. Thereafter, blood smears were negative September 25, 26, 28, October 12, 16, 17, 18, 20, 21, 22, 23, 24, 27, 28, 29, and November 2.

October 12 this bird (L76) received intramuscularly an infective inoculum of blood-saline mixture from N61, a bird whose blood smear on this date was + for *P. cathemerium*. Yet, as noted in the preceding paragraph, blood smears remained negative. On the same date (October 12), however, blood from L76 was injected with N77, N78, and N79. Of these birds N77 and N79 had + blood smears October 21 and N78 October 23 and thereafter.

L76, therefore, still had a chronic infection with *P. cathemerium*, yet this could only be proved by the infectiveness of its blood. From this experience it may be concluded, parenthetically, that cases of spontaneous cure in avian malaria cannot be admitted without proof that the blood is no longer infective to a series of birds.

October 27 this bird (L76) received intramuscularly an infective inoculum of blood-saline mixture from C71, a bird whose blood smear that date was + + + + + for *P. capistrani*. Blood smears were + November 4, 5, 6, 7, 9, 10, 11, 12, and 14. This bird (L76) was still alive November 15.

Bird K5.

This bird received intramuscularly an infective inoculum of blood-saline mixture from K3 June 27, 1931. Blood smears were + for *P. elongatum* July 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and August 10. Smears were negative August 17 and 20.

August 10 this bird (K5) received intramuscularly an infective inoculum of blood-saline mixture from C25, a bird whose blood smear on this date was + for *P. capistrani*. Blood smears from K5 were + for *P. capistrani* August 18, 19, 21, 25; + + + August 27 and 29. This bird died September 10, 1931.

Bird 26RW.

This bird received intramuscularly an infective inoculum of blood-saline mixture from 20RW August 3, 1931. Blood smears were + for *P. relictum* August 14, 15, and 24. Smears were negative August 3, October 27, 28, 29, November 2, 4, 6, 7, and 14.

October 27 this bird (26RW) received intramuscularly an infective inoculum of blood-saline mixture from C71, a bird whose blood on this date was + + + + + for *P. capistrani*. Blood smears from 26 RW were + for *P. capistrani* November 10 and 12.

Bird 28RW.

This bird received intramuscularly an infective inoculum of blood-saline mixture from 20RW August 3, 1931. Blood smears were + for *P. relictum* August 14, 15, October 28, November 4 and 12. Smears were negative August 3, October 27, 29, and November 2.

November 10 this bird (28RW) received intramuscularly an infective inoculum of blood-saline mixture from C91, a bird whose blood on this date was + for *P. capistrani*. Blood smears from 28RW were + for *P. capistrani* November 21, 23, 24, and 25. They were entirely negative November 10 and 19.

Bird 34RW.

This bird received intramuscularly an infective inoculum of blood-saline mixture from 26RW August 24, 1931. Blood smears were + for *P. relictum* September 3, + + + + September 5. Smears were negative November 14.

November 14 this bird (34RW) received intramuscularly an infective inoculum of blood-saline mixture from C89, a bird whose blood was + + + + + for *P. capistrani*. Blood smears were negative November 20, 21, and 24. They were positive for *P. capistrani* November 23.

Bird C1.

This bird received intramuscularly an infective inoculum of blood-saline mixture from wild-caught bird EL5 (*Excalfactoria lineata*) August 4, 1930. Blood smears were negative August 4, 7, 8, 9, 11, 12, 13, and 14. Smears were positive for *P. capistrani* August 15, 16, 18, 19, and 20. Thereafter smears were negative August 21, 22, 28, September 16, 24, 27, October 22, January 2, 1931, February 10, March 10, 12, 16, 17, 18, 23, 27, 28, and 30.

March 23, 1931, this bird (C1) received intramuscularly an infective inoculum of blood-saline mixture from X64, a bird whose blood smear on this day was + for *P. cathemerium*. Blood smears from C1 were + for *P. cathemerium* March 31 and April 1 and 4. They were + + + + April 6 and + April 14, 21, 22, and 23.

April 14 this bird (C1) received intramuscularly an infective inoculum of blood-saline mixture from 13RW, a bird whose blood smear this day was + for *P. relictum*. Blood smears were + for *P. relictum* April 23, 24, 25, 28, and 29. Blood smears were entirely negative April 30.

April 29 this bird (C1) received intramuscularly an infective inoculum of blood-saline mixture from 88RE, a bird whose blood smear this day was + for *P. elongatum*. Blood smears from C1 were + for *P. elongatum* May 9, 11, and 18. They were entirely negative May 12. This bird died July 2, 1931.

Bird C12.

This bird received intramuscularly an infective inoculum of blood-saline mixture from wild-caught bird EL23 (*Excalfactoria lineata*) November 7, 1930. Blood smears were negative November 7, 14, 15, 17, 18, 19, 20, 21, and 22. Smears were positive for *P. capistrani* November 24, 25, and 26. Thereafter smears were negative November 28, December 2 and 4, January 2, March 10, 12, 16, 17, and 18, and April 8, 14, and 16.

April 8 this bird (C12) received intramuscularly an infective inoculum of blood-saline mixture from 13RW, a bird whose blood smear this day was + for *P. relictum*. Blood smears from C12 were + for *P. relictum* April 18, 20, 22, 25, 28, 29.

April 29 this bird (C12) received intramuscularly an infective inoculum of blood-saline mixture from 88RE, a bird whose blood smears this day were + for *P. elongatum*. Blood smears from C12 were positive for *P. elongatum* May 9, 11, and 12. The bird, C12, died May 13, 1931.

Bird C13.

This bird received intramuscularly an infective inoculum of blood-saline mixture from wild-caught bird EL23 (*Excalfactoria lineata*) November 7, 1930. Blood smears were negative November 7, 14, 15, 17, and 18. Smears were + for *P. capistrani* November 19, 20, and 21.

Thereafter smears were negative November 22, 24, 25, 26, and 28, December 2 and 4, January 2, February 10, March 10, 12, 16, 17, and 18, and July 8.

July 8 this bird (C13) received intramuscularly an infective inoculum of blood-saline mixture from 20RW, a bird whose blood smear this day was + for *P. relictum*. Blood smears from C13 were + for *P. relictum* July 18, 20, and 21. They were + + July 22 and 23, and + July 24, 25, and August 10. This bird died August 13, 1931.

Bird C24.

This bird received intramuscularly an infective inoculum of blood-saline mixture from bird C20 April 8, 1931. Blood smears were negative April 8, 14, 16, and 18. They were + for *P. capistrani* April 20, 21, 22, and 25.

July 8 this bird (C24) received intramuscularly an infective inoculum of blood-saline mixture from 20RW, a bird whose blood smear this day was + for *P. relictum*. Blood smear from C24 was + for *P. relictum* July 18. The bird died July 20.

Bird C25.

This bird received intramuscularly an infective inoculum of blood-saline mixture from bird C20 April 8, 1931. Blood smears were negative April 8, 14, and 16. They were + for *P. capistrani* April 18 and 22, July 8, 14, 16, and 22, and August 10. They were negative July 25 and August 24.

August 10 this bird (C25) received intramuscularly an infective inoculum of blood-saline mixture from K5, a bird whose blood smear this day was + for *P. elongatum*. Blood smears from C25 were + for *P. elongatum* August 10, 19, 20, 21, and 22. This bird died August 30, 1931.

Bird C30.

This bird received intramuscularly an infective inoculum of blood-saline mixture from C28 June 1, 1931. Blood smears were negative June 1, 8,

and 9. They were positive for *P. capistrani* June 11, 13, and 20; negative June 15, 17, and 18.

June 18 this bird (C30) received intramuscularly an infective inoculum of blood-saline mixture from L90, a bird whose blood smear this date was + + + + for *P. cathemerium*. Smears from C30 were + for *P. cathemerium* June 22, 23, and 24, + + June 25, + + + + June 26, and + + + + + June 27. This bird died June 28, 1931.

Bird C44.

This bird received intramuscularly an infective inoculum of blood-saline mixture from bird C42 August 22, 1931. C42 had been infected with a parasite obtained from a wild-caught bird—*Turnix fasciata*—through the following passages: July 31, 1931, *Turnix fasciata* to C37. August 15, 1931, C37 to C42.

This parasite was probably *P. elongatum*, as it resembled this species morphologically and could not be transmitted to birds with known *P. elongatum* infections. Bird C44, therefore, was probably infected with a local strain of *P. elongatum*.

Blood smears from C44 were negative August 22, 27, and 29. They were positive August 31, September 2, 4, and 7. These smears contained elongate gametocytes. Blood smears were negative September 24, 26, 28, and 29, and October 1.

September 26 this bird (C44) received intramuscularly an infective inoculum of blood-saline mixture from C40, a bird whose blood smear this day was + for *P. capistrani* sp. nov. Blood smears from C44 were + for *P. capistrani* October 3, 5, 6, and 7; + + October 8; + + + + + October 9. This bird was alive November 15.

Bird C68.

This bird received intramuscularly an infective inoculum of blood-saline mixture from C29 September 26. Blood smears from C68 were negative September 26 and October 5. They were positive for *P. capistrani* October 6 and 7, + + + October 13, 15, 17 and 20, negative October 24.

November 14 this bird (C68) received intramuscularly an infective inoculum of blood-saline mixture from 34RW, a bird whose blood smear had been + + + + for *P. relictum* September 5 but was negative November 14. Blood smears were negative November 19, 20, 21, 23, 24, 25, and 27 but were + for *P. relictum* November 28 and December 1.

SUMMARY

The discovery is reported of a new plasmodium of avian malaria which it is proposed to call *Plasmodium capistrani*.

Descriptions and drawings are given of this parasite in its various phases. Mosquito transmission is reported and also cross-infection experiments with three common species of avian malaria plasmodia.

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ILLUSTRATIONS

PLATE 1

FIGS. 1 to 8. *Plasmodium capistrani* sp. nov. *1* and *2*, Young trophozoites; *3* and *4*, older asexual forms; *5* and *6*, segmenting forms; *7*, microgametocyte; *8*, macrogametocyte.

9 to 11. *Hæmoproteus* from *Aluco longimembris.*

12 to 14. *Hæmoproteus* from *Excalfactoria lineata.*

FIG. 15. *Plasmodium elongatum* Huff, 1930, from *Turnix fasciata.*

All figures in Plate 1 are × 3,000.

PLATE 2

FIG. 1. Oöcyst of *Plasmodium capistrani* sp. nov. on stomach wall of *Culex quinquefasciatus;* diameters 38 × 43 μ. (Photograph by the Bureau of Science.)

2. Sporozoites of *Plasmodium capistrani* sp. nov. near ruptured salivary gland of *Culex quinquefasciatus;* × 500. (Photograph by the Bureau of Science.)

TEXT FIGURE

FIG. 1. Lines of transmission of *Plasmodium capistrani* sp. nov.

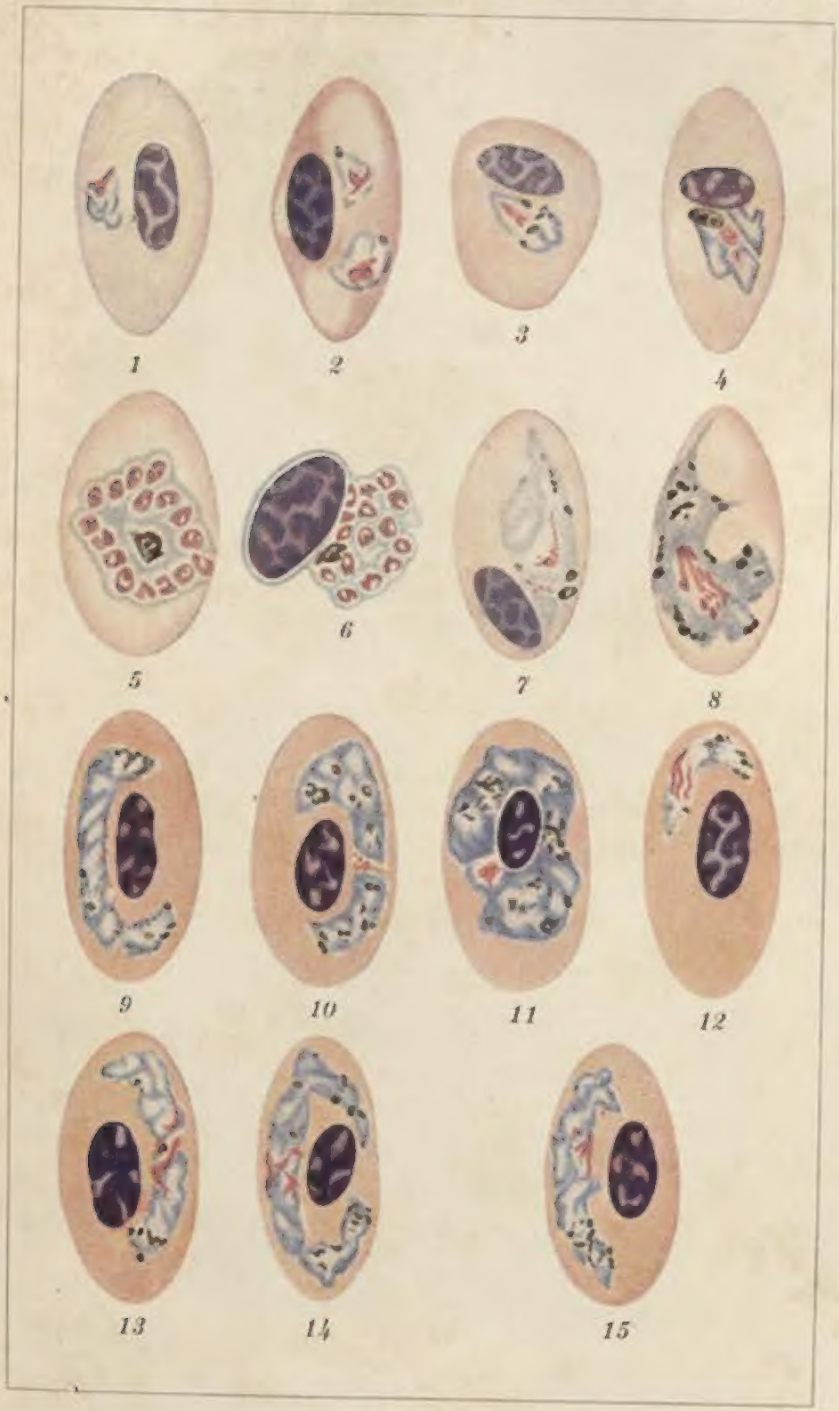

PLATE 1.

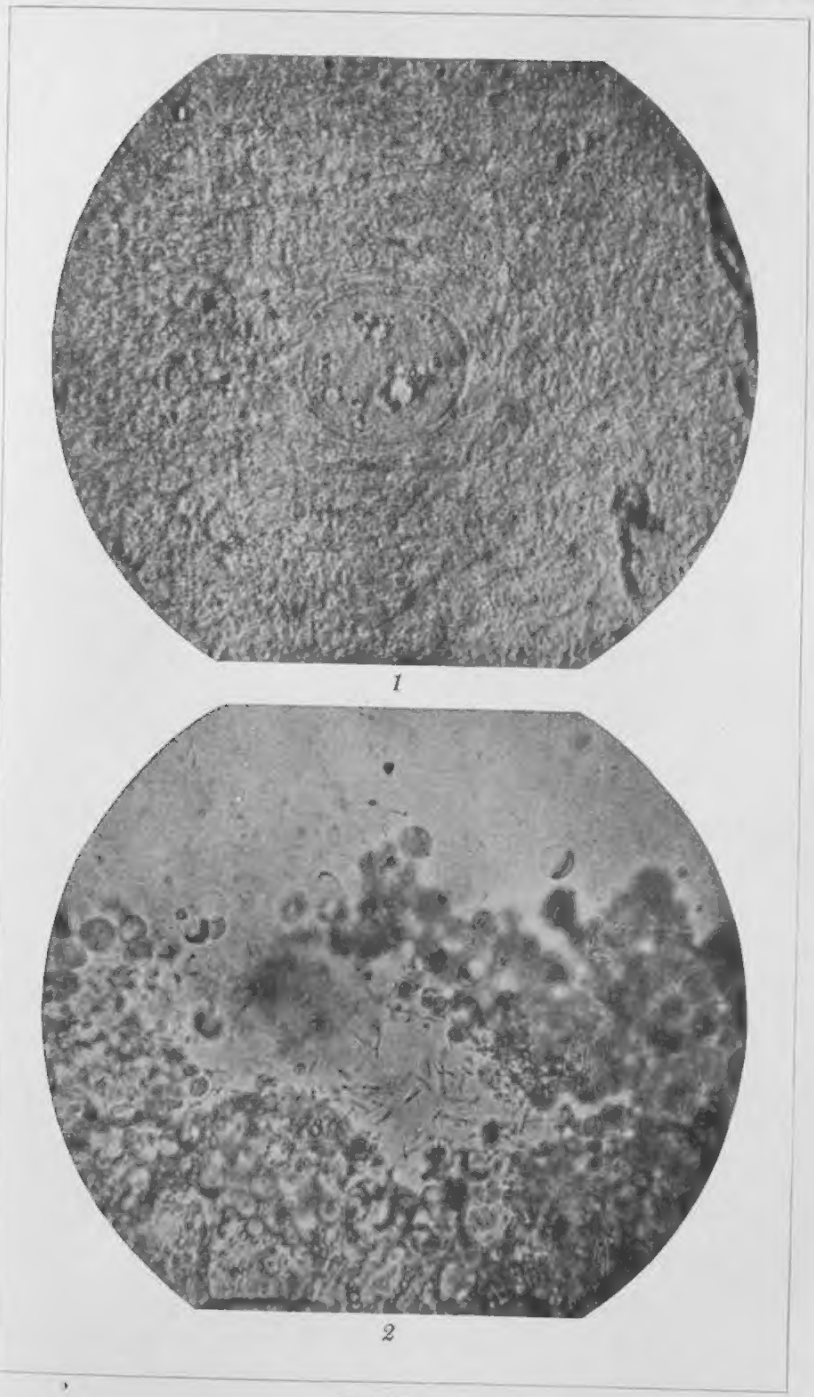

PLATE 2.